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(Diptera: Empididae: Ragadinae subfam. nov.)

by

Bradley J. Sinclair

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Revision of the Australian species of *Hydropeza* Sinclair (Diptera: Empididae: Ragadinae subfam. nov.)

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ABSTRACT. Nine new species of *Hydropeza* Sinclair from Australia are described (*H. angulata* sp. nov. (N. Queensland), *H. aptera* sp. nov. (Tasmania), *H. cornuta* sp. nov. (Queensland), *H. curvata* sp. nov. (N. Queensland), *H. divaricata* sp. nov. (N. Queensland), *H. intricata* sp. nov. (N. Queensland), *H. queenslandensis* sp. nov. (N. Queensland), *H. tasmanica* sp. nov. (Tasmania), *H. unguicula* sp. nov. (Tasmania)). In Australia, *Hydropeza* is currently widely disjunct in distribution, known only from Tasmania and northern Queensland (Wet Tropics), absent from intervening regions despite extensive surveys of rocky streams and creeks. The male terminalia are illustrated, distributions mapped and a key to species is presented. The subfamily Ragadinae subfam. nov. is proposed for the *Ragas*-group of genera (*Dipsomyia* Bezzi, *Hormopeza* Zetterstedt, *Hydropeza*, *Ragas* Walker, *Zanclostus* Wilder). A revised phylogeny of the species of *Hydropeza*, including species from New Zealand and Chile, is presented and discussed.

KEYWORDS. Diptera; Empididae; *Hydropeza*; new species; taxonomy; Australia

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The genus *Hydropeza* Sinclair was erected for a New Zealand species described by Miller (1923), which was originally assigned to the Northern Hemisphere genus *Trichopeza* Rondani (Sinclair, 1999). There are ten New Zealand species and a single species described from Chile (Sinclair & McLellan, 2004; Sinclair & Plant, 2008).

In Australia, *Hydropeza* was initially recognized from a large-sized undescribed Tasmanian species collected from streams and rivers (Fig. 5). More recently this genus was discovered from northern Queensland, where a series of new species are represented. The apparent rarity of the genus is in part likely due to the curious habit of the adults which fly rapidly about small cascades and pools with all

six legs skimming on the water surface, making them hard to see especially in shaded streams and very difficult to capture with sweep nets. The author used small dip nets to collect individuals, which were virtually invisible at the base of small cascades. In addition, the use of lights set next to streams, Malaise traps set across streams, as well as pitfall traps and yellow pan traps have proven effective in capturing specimens. This paper reports on the Australian biotic diversity of *Hydropeza* for the first time.

Hydropeza is assigned to the *Ragas* genus-group (Sinclair & Cumming, 2006), which is herein elevated to subfamily rank. The new subfamily is newly diagnosed and discussed.

Material and methods

This study was based on the examination of 229 adult specimens borrowed from or deposited in the following institutions or collections: Australian Museum, Sydney (AMS); Australian National Insect Collection, Canberra, Australia (ANIC); Canadian National Collection of Insects, Ottawa, Canada (CNC); Museum Victoria, Melbourne (NMV).

Terms used for adult structures primarily follow those of Cumming & Wood (2009), except for the antenna and wing venation, where the terms of Stuckenberg (1999) and Saigusa (2006) are used, respectively. To facilitate observation, terminalia were macerated in hot 85% lactic acid and immersed in glycerin. All specimens are dried and mounted on pins. Label data of holotypes are cited in full, with original spelling, punctuation and date; lines are delimited by a slash mark (/), and a semicolon separates data quoted from different labels. Secondary type data are abridged and listed alphabetically.

The following abbreviations are used in the descriptions and material examined sections: *acr*—acrostichal setulae; *bm-m*—basal medial-medial crossvein; *ck*—creek; *CuA*—anterior branch of cubital vein; *CuP*—posterior branch of cubital vein; *dc*—dorsocentral setae; *dm*—discal medial cell; *MT*—Malaise trap; *NP*—National Park; *npl*—notopleural setae; *pal*—postalar setae; *ph*—posthumeral seta; *pprn*—postpronotal setae; *presut spal*—presutural supra-alar setae; *psut spal*—postsutural supra-alar setae; *R*—radial vein; *sctl*—scutellar bristles; *T*—tergite; *ypans*—yellow pan traps.

A cladistic analysis of the species level relationships of

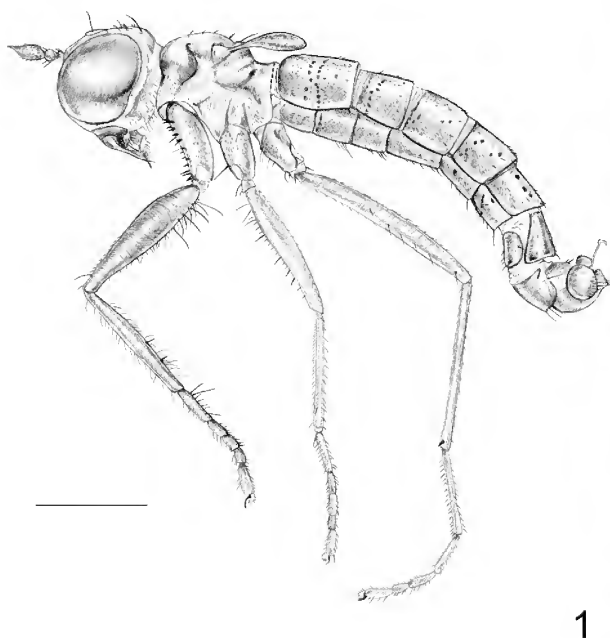
the genus *Hydropeza* was performed using the parsimony program PAUP*4.0b10 (Swofford, 1998). A heuristic search with stepwise addition was implemented to find the most parsimonious trees using random addition sequence of taxa, tree-bisection-reconnection (TBR) branch swapping and 1000 random replications. All characters were unordered and of equal weight, MulTrees option in effect, with ACCTRAN optimization. The data matrix (Table 1) consisted of 22 morphological characters, including 2 multi-state characters (Table 2), compiled for 16 species of *Hydropeza*, which included all Australian and Chilean species and a selection of New Zealand species. *Hormopeza senator* Melander was used as the outgroup taxon and to root the trees.

Taxonomy

Subfamily Ragadinae subfam. nov.

Type-genus: *Ragas* Walker, 1837: 229.

Diagnosis. Males dichoptic or holoptic; eyes with or without ommatrichia; scape with setae (absent in *Hormopeza* Zetterstedt); labrum stout and recurved at least in females, lacinia freely projecting; apical epipharyngeal comb present (absent in *Hydropeza*); laterotergite bare (except *Dipsomyia* Bezzi); fore coxa with erect, spine-like setae (absent in *Hormopeza*); costa circumambient (although sometimes weakened posteriorly); R_{4+5} branched; apex of phallus often emitting membranous tube; female cercus short, broad with fine setae (Sinclair, 1999; Sinclair & Cumming, 2006).



Figures 1–2. (1) *Hydropeza aptera* (drawn by Hannah Finlay). (2) McPartlan Pass, Tasmania, type-locality of *H. aptera* (photograph: M. Driessen). Scale bar = 0.5 mm.

Remarks. The *Ragas* genus group was first proposed by Sinclair (1999) and keyed out from other major groups of Empidoidea by Sinclair & Cumming (2006). The group is herein given subfamily status, although its precise position within the Empididae remains unresolved (Sinclair & Cumming, 2006). The subfamily is named to provide stability in Empidoidea nomenclature, and to highlight the importance of including this clade in future molecular and morphological phylogenetic studies.

The presence of Baltic amber species of *Ragas* Walker indicates that the subfamily is as old as the Dolichopodidae s.str. (minimum age: 40 million years) and could perhaps be found in Upper Cretaceous amber (Ulrich, 2003; Sinclair & Hoffeins, 2013). The Gondwanan distribution of *Hydropeza* implies an even older minimum age (see below).

The Ragadinae includes the genera: *Dipsomyia* Bezzi, *Hormopeza* Zetterstedt, *Hydropeza* Sinclair, *Ragas* Walker, and *Zanclostus* Wilder (Sinclair, 1999; Sinclair & Cumming, 2006). Only *Hydropeza* and *Hormopeza* are recorded from Australia (Sinclair, 1995).

Etymology. The type genus, *Ragas* (gender feminine) is derived from the Greek word *rhagás* (ῥαγᾶς), with genitive *rhagádos* (Latin *rhagadis*), which in medicine refers to fissures or cracks in the skin. It is not obvious what its meaning might have in common with the fly named by Walker. Given the Greek source of the generic name, the stem of *Ragas* is ragad- and consequently the subfamily is Ragadinae (Ulrich, pers. comm.).

Genus *Hydropeza* Sinclair

Hydropeza Sinclair, 1999: 135. Type-species: *Hydropeza longipennae* (Miller).

Diagnosis. This genus can be identified using the key to subfamilies and genus groups in Sinclair (2011), characterized by its long and apically rounded cell cua, pterostigma absent (Fig. 28), pubescent eyes (Fig. 13), fore coxa with spine-like setae (Fig. 14), bare laterotergite and recurved labrum (Figs 1, 3–6, 13).

Description. See Sinclair (1999) for description, with the following addition: male cercus undivided and continuous posteromedially with subepandrial sclerite or often subdivided into short anterior lobe and short to elongate posterior lobe (often termed clasping cercus); posterior cercus medially continuous with subepandrial sclerite.

Remarks. There are 11 described species of *Hydropeza* from New Zealand and Chile (Fig. 30) (Sinclair & McLellan, 2004; Sinclair & Plant, 2008). This study builds on these studies and describes the nine species from Australia. In a preliminary phylogenetic analysis, the *H. longipennae*-group of New Zealand was assigned as sister to the remaining species of the genus. The remaining New Zealand species were assigned to a monophyletic clade (Sinclair & McLellan, 2004). The phylogeny of the *Hydropeza* is reanalysed in this study (see below).

Key to Australian species of *Hydropeza*

Most females from Queensland are not readily identifiable due to similar terminalia and uncertainty concerning variation. More study on positively associated females from Queensland is required.

- | | | |
|---|---|-------------------------------|
| 1 | Wings reduced to halter-like appendages; head and body chaetotaxy greatly reduced and slender; eyes closely approximated below antennae (Figs 1, 3) | <i>H. aptera</i> sp. nov. |
| — | Wings fully developed; head and body chaetotaxy very long and bristle-like (Figs 4–6); eyes widely separated below antennae | 2 |
| 2 | Acrostichal setae present posterior to first pair of dorsocentral setae (females not readily distinguishable in the following species) | 3 |
| — | Acrostichal setae confined anteriorly to first pair of dorsocentral setae | 5 |
| 3 | Male cercus unforked; phallus inflated with highly modified apex comprised of lobes and jagged edges (Fig. 24); female abdominal segment 8 distinctly swollen | <i>H. intricata</i> sp. nov. |
| — | Male cercus forked; phallus flattened with simple apex; female segment 8 not swollen | 4 |
| 4 | Male cercus U-shaped; upper branch straight with apex rounded (Fig. 23) | <i>H. divaricata</i> sp. nov. |
| — | Male cercus V-shaped; upper branch slightly twisted with narrow apex (Fig. 12) | <i>H. curvata</i> sp. nov. |

- 5 Arista-like stylus subequal to or longer than length of postpedicel; male hind femur swollen, wider than mid femur (as in Fig. 4), slender in female; hind tarsomere 4 unmodified in both sexes, not laterally compressed 6
- Arista-like stylus shorter than length of postpedicel; hind femur slender in both sexes, not broader than other femora (Figs 5, 6); hind tarsomere 4 laterally compressed in both sexes, with ventral keel 8
- 6 Disc of scutellum with numerous long setulae; male cercus Y-shaped, apex of surstylus with straight spine-like projection; postgonite digitiform, erect and extending beyond margin of epandrium (Fig. 25) *H. queenslandensis* sp. nov.
- Disc of scutellum with at most 1–2 pairs of long setulae; male terminalia otherwise 7
- 7 Arista-like stylus 2.5 times length of postpedicel; male cercus unforked, lying horizontally on epandrium, apex bent medially at right angle; apex of surstylus strongly rounded with stout setae on inner face; postgonite short, broad and truncate (Fig. 9) *H. angulata* sp. nov.
- Arista-like stylus only slightly longer than postpedicel; male cercus antler-like, lower branch shorter than upper; apex of surstylus strongly hooked and arched anteromedially; postgonite sickle-shaped and hooked (Fig. 11) *H. cornuta* sp. nov.
- 8 Large species, wing at least 6 mm long (Fig. 5); face with row of long setulae on inner margin of eye (Fig. 13); scutellum with setae confined to margin; male foreleg with tarsomere 1 unmodified; male mid femur modified with knob-like ventral process (Fig. 15) *H. tasmanica* sp. nov.
- Smaller species, wing less than 4 mm long (Fig. 6); face lacking setulae; scutellum with setulae dorsally on disc; male foreleg modified with claw-like process on tarsomere 1 (Fig. 18); male mid femur without knob-like ventral process *H. unguicula* sp. nov.

Hydropeza angulata sp. nov.

Figs 7, 9

Type material. Holotype ♂, labelled: “AUST: N.QLD:/ 31.6km/ up Mt. Lewis Rd., 860m/ 21.iv.1994, cascading/ creek, B. J. Sinclair/ 16°30'S 145°17'E”; “HOLOTYPE/ *Hydropeza/ angulata/ Sinclair* [red label]” (AMS). Paratypes: **Queensland:** 1♂, 2♀♀, 14.7 km up Mt. Lewis Rd., 860 m, 22.iv.1994, cascading ck, 16°30'S 145°17'E, B. J. Sinclair (CNC); 1♂, 4♀♀, same data as holotype (AMS).

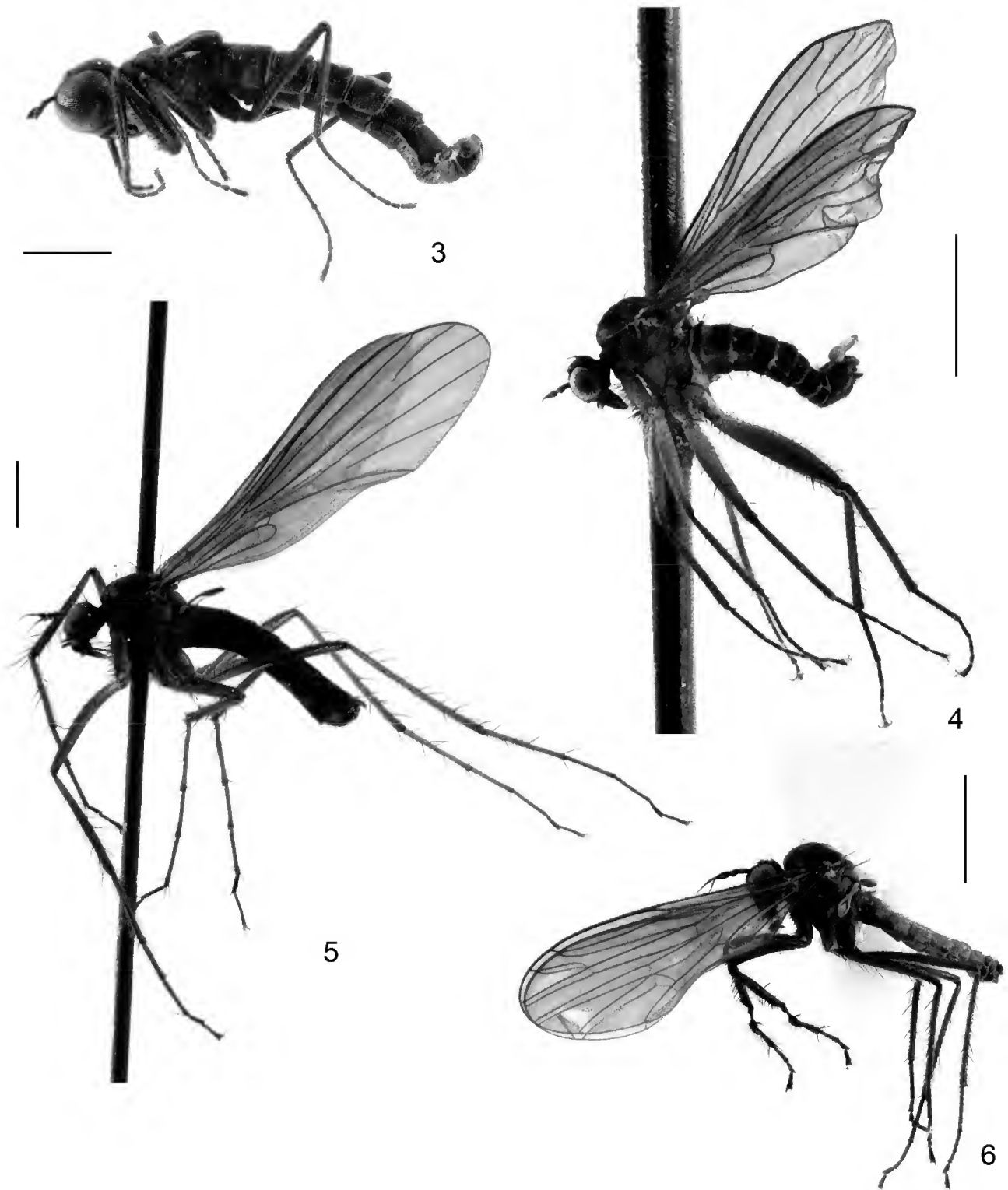
Diagnosis. This species is distinguished from other Queensland species by acrostichal setae confined anteriorly of an imaginary line connecting the first (anteriormost) dorsocentral setae; arista-like stylus 2.5× length of postpedicel; male scutellum with 0–1 pair of elongate discal setae; male mid femur with row of short basal posteroventral setae and mid tibia with short row of spine-like setae on apical third; male hind trochanter without spine-like anteroventral setae; and male cercus unbranched, with apex bent at right angle medially. Females are distinguished from all other species by discal setae mostly absent on the scutellum and segment 8 generally retracted within the abdomen and flattened.

Description. Head and abdomen dark brown, thorax brown with paler patches; coxae brownish yellow, legs

progressively darker towards tips. Wing length 4–4.2 mm.

Male. Head. Ocellar setae very long, erect, divergent, inserted posterior to anterior ocellus; ocellar tubercle with some long setulae; postocellar seta stout and dark; upper postocular setae stout and dark, lower setae fine and slender; postgenal setae similar to lower postoculars. Face without setulae. Scape, pedicel and inner base of postpedicel slightly paler than remaining postpedicel; scape short and slender, slightly longer than length of globular pedicel; postpedicel not greatly prolonged, less than 2× longer than scape, basal portion elongate-oval, 2× longer than tapered apical portion; arista-like stylus 2.5× longer than postpedicel, concolorous with postpedicel. Proboscis stout and robust, extended beyond mid-length of fore coxa, directed posteriorly; palpus half-length of proboscis, clothed in long pale and dark setae; apex of palpus rounded; apical third of palpus flattened with dense pubescence.

Thorax. Clothed in fine pruinescence; mesonotum brown, with postpronotal lobe, lateral margin and postalar ridge pale brown; pleura paler than notum, pale along sutures. Setae generally long and stout; 2–4 acrostichal setulae confined anterior to 1st dorsocentral setae, less than 0.5× length of dc; pprn with 1 seta and 1–2 short setulae; 1 long presut spal; 5 uniserial dc, about subequal in length with several setae interspersed; 3 npl; 1 long psut spal and several shorter anterior setae; 1 pal seta and 1–2 pale setulae; 1 pair of sclt,

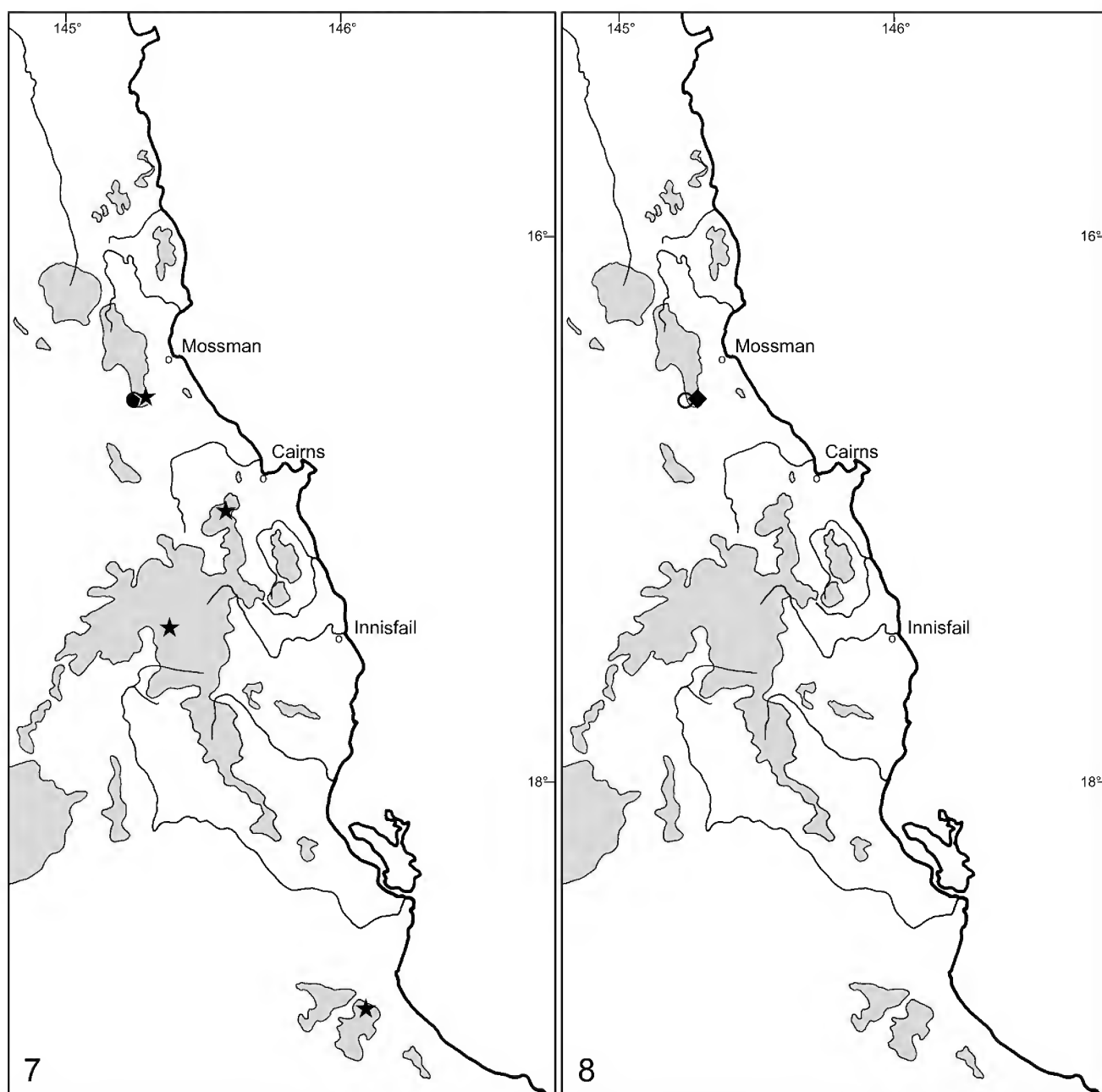


Figures 3–6. Habitus images of dried mounted male species of *Hydropeza*, lateral view. (3) *H. aptera*. (4) *H. intricata*. (5) *H. tasmanica*. (6) *H. unguicula*. Scale bars = 1.0 mm, except Fig. 3 where scale bar = 0.5 mm.

with 1 pair of finer outer marginal setae; disc of scutellum with 0–1 pair of long setae. Antepronotum with pair of pale setulae.

Legs. Coxae and femora ventrally yellowish-brown; remaining segments increasingly darker apically. Inner anterior margin of fore coxa with some 15–20 dark, variously lengthened and thickened spine-like setae, mostly concentrated apically; basal most seta longer than width of coxa. Anterior surface of mid and hind coxae with long brown

setae. Legs clothed in very long setae as typical for genus, especially ventral faces. Fore femur straight, inflated (subequal in thickness to mid femur), with row of 2 stout anterior setae at apical fifth; 4–6 posterodorsal setae, apical 2 setae distinctly stouter. Fore tibia with 3 anteroventral setae on apical third; 2 anterodorsal and 2 posterodorsal setae; 1 anterodorsal preapical seta. Fore tarsomere 1 with 1 basal anteroventral and 1 preapical anteroventral seta, more than 2× width of segment;



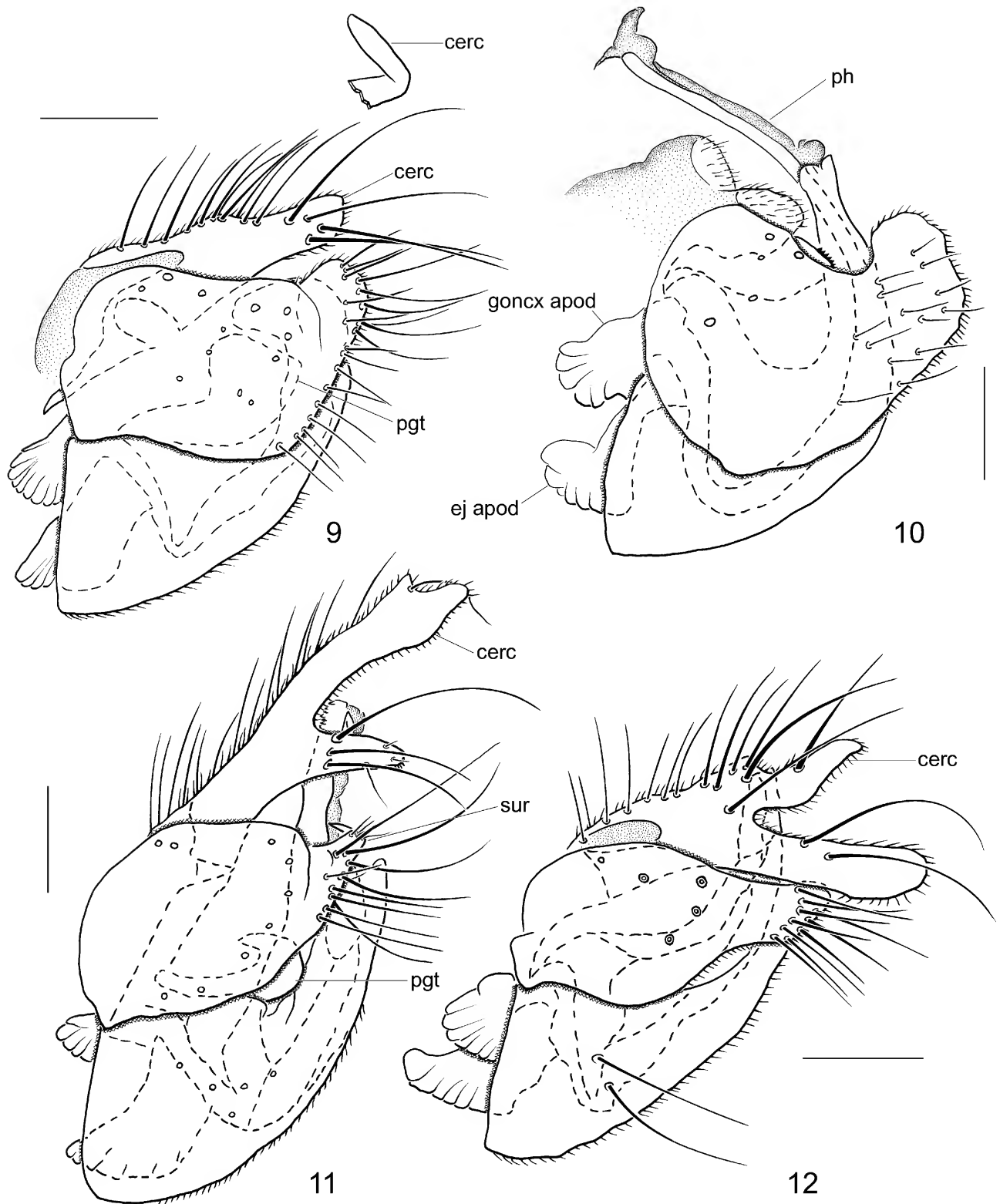
Figures 7–8. Known distribution of the *Hydropeza* species: (7) *H. angulata*; (●), *H. queenslandica*; (★); (8) *H. cornuta*; (○), and *H. curvata*; (◆). Shaded areas indicate land above 700 m in altitude.

1 long basal ventral, 2–4 shorter ventral setae at middle and apex. Mid femur with row of 4 anterodorsal setae stouter towards apex; 1 anterior and 2 posterodorsal setae on apical third; basal half with row of 7–10 short, stout posteroventral setae, less than width of femur; apex with 1 anterior, 1 dorsal and 1 posterior preapical seta. Mid tibia with width reduced on ventral apical third, with row of 9–11 short spine-like setae; apex with 1 short, spur-like ventral and anterodorsal seta; 1 anterodorsal and 2 posterodorsal setae; apex with 1 dorsal seta. Mid tarsomere 1 with 1 long anteroventral and 1 posteroventral basal seta; apex with several preapical setae. Hind femur greatly inflated, nearly 2× broader than fore or mid femora, without erect dorsal setae; with anteroventral row of stout setae along apical third; apical fourth with 2–6 anterodorsal, 1–2 posterodorsal, 1 anterior and 1 posterior seta.

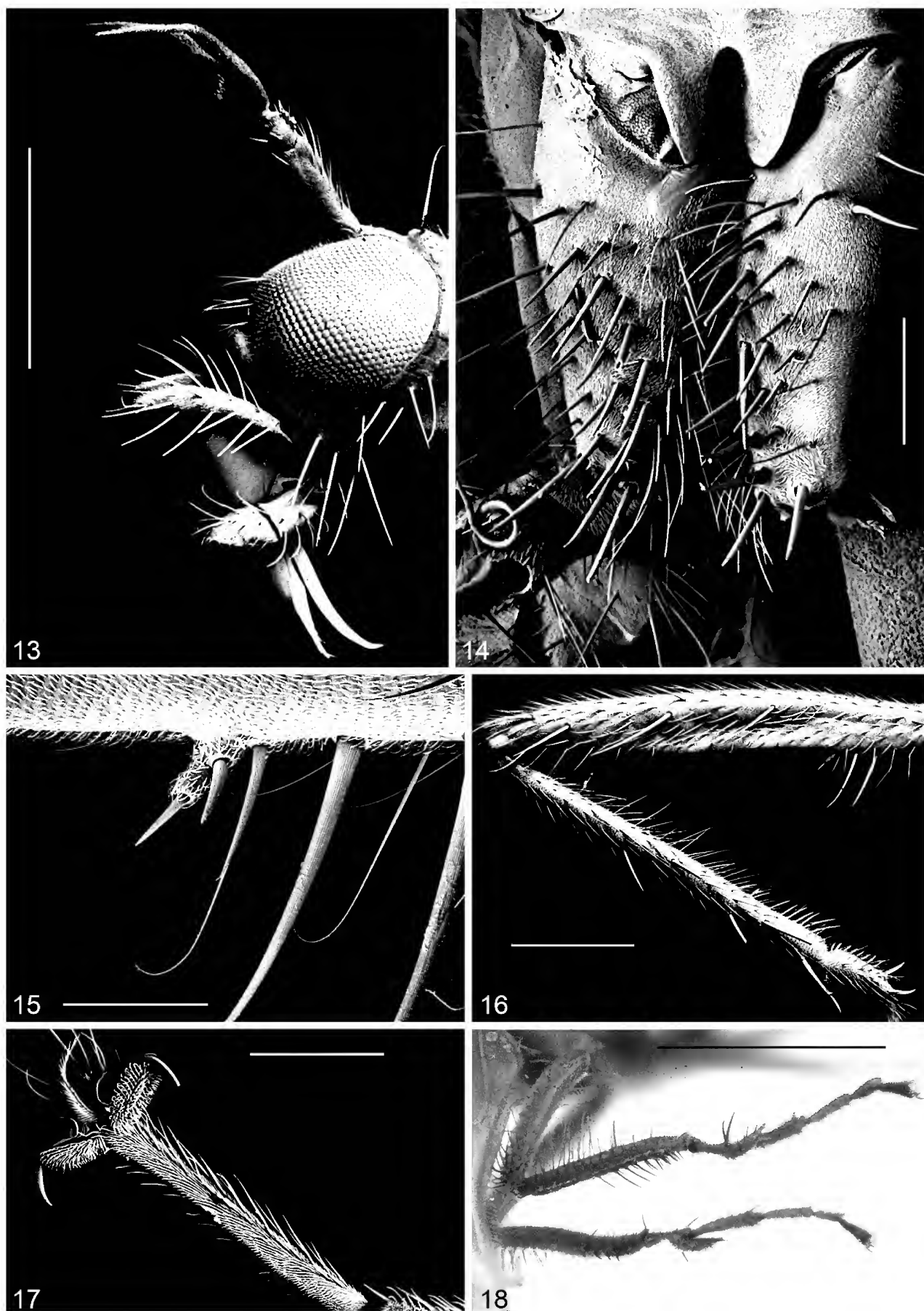
Hind trochanter without spine-like anteroventral setae. Hind tibia with 1 anterodorsal, 1 anteroventral and 1 posterodorsal seta; 1 preapical anterodorsal and 1 apical anteroventral seta; apical fourth with dense posterior setae. Hind tarsomere 1 without erect setae. Fore and mid tarsomeres slightly longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs somewhat pale, flattened and expanded; tarsomere 4 and apical third of tarsomere 3 of hindleg slightly laterally compressed ventrally; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Infusate with 1 long basal costal seta, longer than sc1; all veins lacking setulae; R_4 and R_5 distinctly divergent apically; bm-m complete; cell dm truncate, longer than cell bm; CuA + CuP reduced to streak. Halter brown.

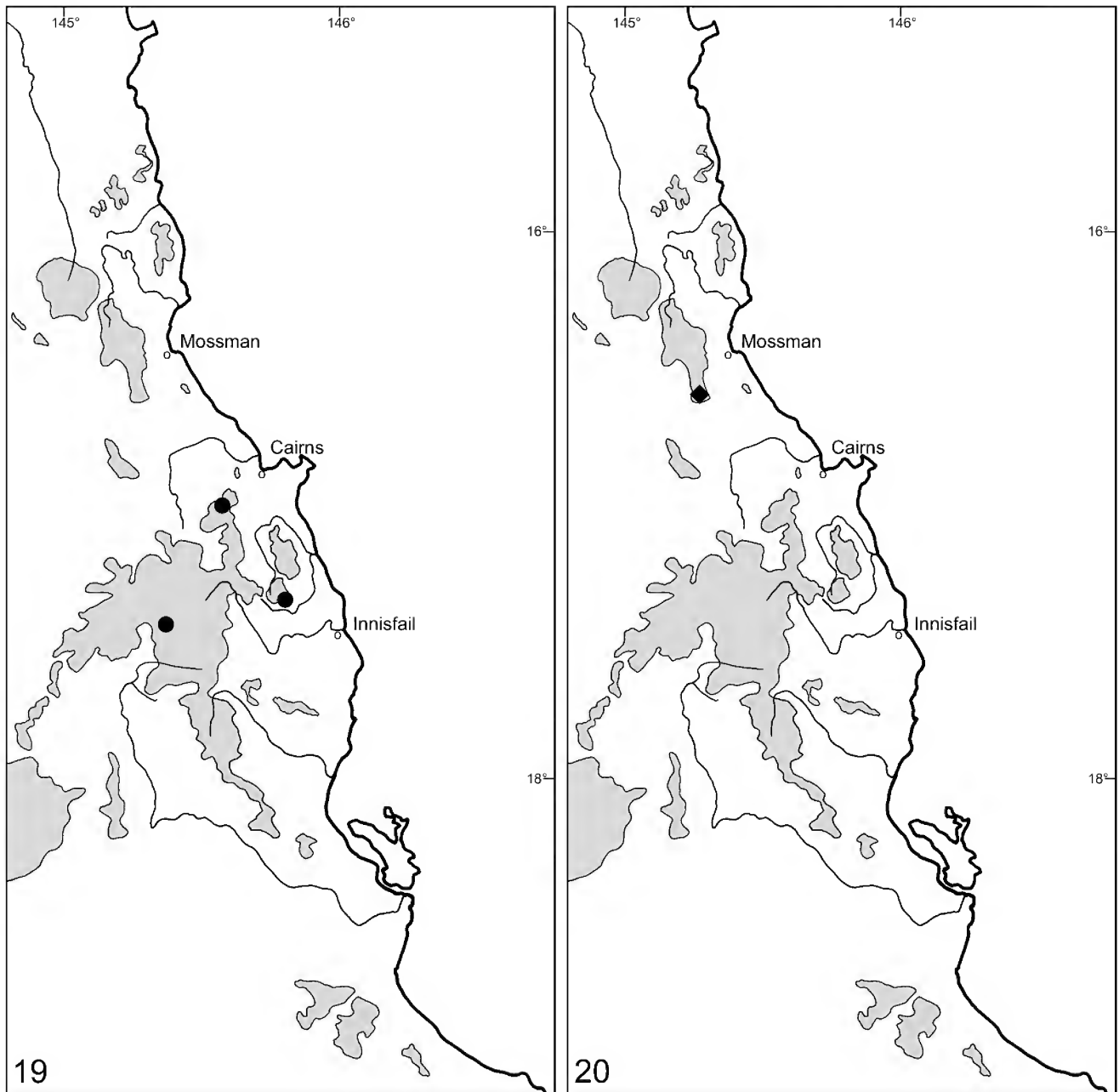
Abdomen. Tergites and sternites clothed in setae; setae



Figures 9–12. Male terminalia of *Hydropeza*, lateral view. (9) *H. angulata* (inset showing inner apex of cercus). (10) *H. aptera*. (11) *H. cornuta*. (12) *H. curvata*. Abbreviations: *cerc*, cercus; *ej apod*, ejaculatory apodeme; *goncx apod*, gonocoxal apodeme; *pgt*, postgonite; *ph*, phallus; *sur*, surstylus. Scale bars = 0.1 mm.



Figures 13–18. Scanning electron photographs of *Hydropeza tasmanica* and digital image of foreleg of *H. unguicula*. (13) Head (scale bar = 0.5 mm) (from Sinclair & McLellan, 2004, fig. 10). (14) Fore coxae (scale bar = 0.2 mm). (15) Male mid femur (scale bar = 0.1 mm). (16) Male mid femur and tibia (scale bar = 0.5 mm). (17) Tarsomere 5 and acropod (scale bar = 0.2 mm). (18) Male forelegs of *H. unguicula* (scale bar = 1.0 mm).



Figures 19–20. Known distribution of the *Hydropeza* species: (19) *H. divaricata* sp. nov. (●) and (20) *H. intricata* sp. nov. (◆). Shaded areas indicate land above 700 m in altitude.

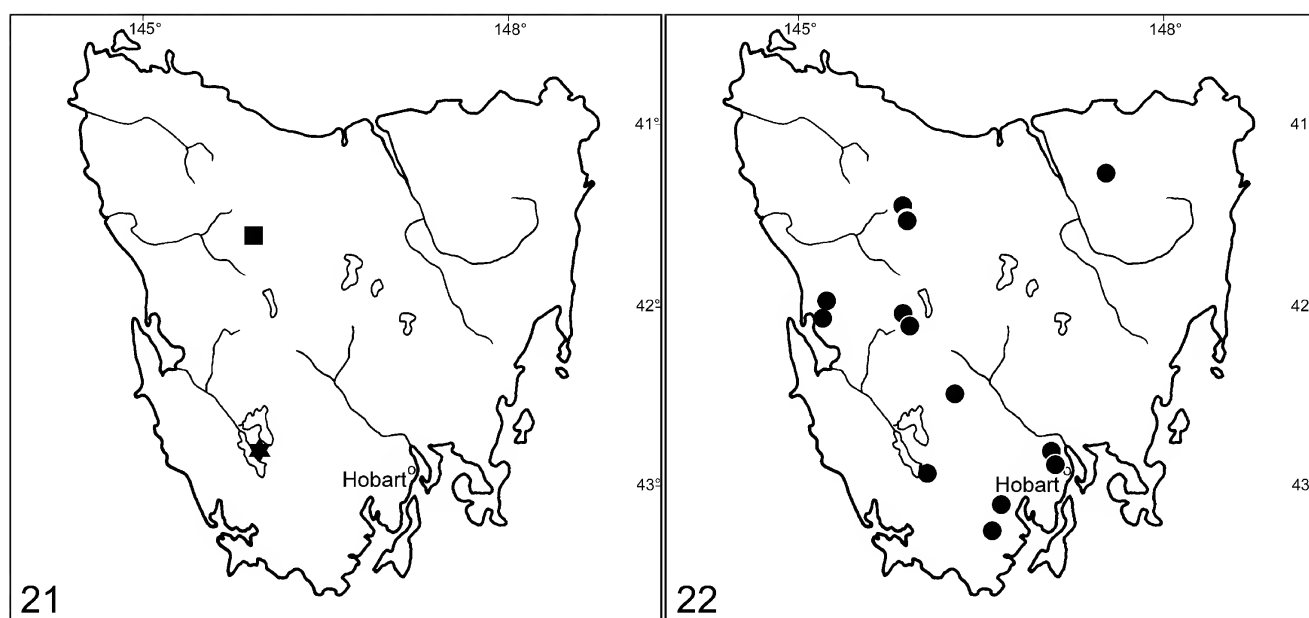
of posterior margin overlapping more than half length of following tergite. T8 broad, nearly one-half length of T7; posterior marginal setae slender, some 1.5× length of tergite.

Terminalia (Fig. 9). Cercus projected horizontally, shorter than epandrium, not forked or subdivided; apex sharply bent at right angle medially, nearly touching opposing cercus. Epandrium broad with scattered setae. Surstylus short, with broadly rounded apex, not arched medially; inner margin with cluster of some 8 stout setae. Hypandrium subrectangular broad; apical margin not notched; gonocoxal apodeme broad, rounded; postgonite broad, short and L-shaped, touching opposing postgonite medially. Phallus broad with apex inflated; ejaculatory apodeme straight, longer than gonocoxal apodeme.

Female. Similar to male except as follows: scutellum with 1 pair of discal setae; mid femur lacking row of stout posteroventral basal setae; mid tibia not narrowed apically, lacking row spine-like setae; hind femur not strongly inflated, lacking anteroventral row of stout setae. Terminalia (not dissected): segment 8 not inflated, broad; cercus slightly longer than epiproct, nearly 2× longer than wide; broad with rounded apex.

Distribution. This species is recorded from above 800 m on Mt. Lewis, Queensland (Fig. 7).

Etymology. The specific name is from the Latin *angulatus* (with angles), in reference to the right angle bend of the male cercus.



Figures 21–22. Known distribution of the new *Hydropeza* species: (21) *H. aptera* sp. nov. (★); *H. unguicula* sp. nov. (■); and (22) *H. tasmanica* sp. nov. (●).

Hydropeza aptera sp. nov.

Figs 1–3, 10, 21

Type material. Holotype ♂, labelled: “TAS: McPartlan Pass./ 42°51'S 146°11'E/ pitfall ARE(Y); 17./ viii.1999; M. Driessen”; “HOLOTYPE/ *Hydropeza/ aptera/ Sinclair* [red label]” (AMS). Paratypes: **Tasmania:** 1♂, same data as holotype, except ARE(Y)4, 14.ix.1999 (AMS); 1♀, same data as holotype, except ARE(Y)8, 28.vii.1999 (AMS); 2♂♂, McPartlan Pass, buttongrass moorland, 28.vii.1999, pitfall tp, TRW6, 42°51'12"S 146°12'39"E, 320 m, M. Driessen (CNC); 1♀, ditto, except TRE(0) 16.v.2000 (CNC); 1♂, 4♀♀, Airstrip Rd, sites 1A–6P, 42°51'5"S 146°11'24"E, pitfall tp, 29.v.–5.vi.2001, M. Driessen (AMS); 4♂♂, 1♀, ditto, except ARE(Y), 42°50'30"S 146°14'36"E, 320 m, M. Driessen (AMS, CNC).

Diagnosis. This is the only apterus species of *Hydropeza*, with the wings reduced to halter-like appendages and legs and scutum with reduced chaetotaxy.

Description. Head and thorax dark brown to black with greyish pruinescence, abdomen brown to black with thin pruinescence; legs dark brown. Wing appendage length 0.3–0.4 mm.

Male. Head. Oval, produced posterodorsally, somewhat flattened dorsally. Ocellar setae short, erect, divergent, inserted between posterior and anterior ocelli; ocellar tubercle with some short setulae; postocellar and postocular setae short and slender; postgenal setae pale, slender, longer than postocellar setae. Face very narrow, closely approximated, lacking setulae. Scape short and slender, subequal in length to pedicel; postpedicel pointed-ovate, longer than scape and pedicel combined, with very short knob-like apical stylus. Proboscis stout and robust, short, extended well beyond mid-length of fore coxa, directed posteriorly; palpus very short, oval about 0.15× length of proboscis, clothed in pale setae; apex of palpus rounded.

Thorax. Greatly shortened and reduced due to apterus condition. Clothed in fine pruinescence; mesonotum with chaetotaxy reduced; scutellum shorted with pair of short, pale apical setae.

Legs. Brown, fore coxa with fine pruinescence, similar to thorax. Inner anterior margin of fore coxa with some 20 dark spine-like setae, mostly concentrated apically and mid-basally; setae not longer than width of coxa. Anterior surface of mid and hind coxae with long brown setae. Legs lacking long, fine setae. Fore femur distinctly broader than mid and hind femora; basal third with 4 long posteroventral setae, longer than femur width; anteroventral face with fine, pale setae. Fore tibia with 4 anteroventral, 2 posteroventral spine-like setae. Fore tarsomere 1 with 4 anteroventral and 4 posteroventral stout setae, anteroventral setae nearly twice longer than posteroventral setae. Mid femur with 4–5 posteroventral setae, nearly as long as width of femur; anteroventral row of short, spine-like setae along entire length. Mid tibia lacking distinct erect setae. Mid tarsomere 1 lacking distinct setae. Hind femur with erect dorsal setae; 1 preapical anterior, 2–3 preapical anteroventral setae. Hind tibia with 1 stout preapical anteroventral seta. Hind tarsomere 1 with biserial row of ventral setae. Tarsomeres of hindleg much longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs not flattened and expanded; tarsomere 4 of hindleg not laterally compressed ventrally; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Reduced to halter-like appendage; concolorous with thorax. Halter absent.

Abdomen. Tergites and sternites with short, sparse setae; marginal setae not lengthened. T8 broad, more than half length of T7; setae similar to preceding segments.

Terminalia (Fig. 10). Cercus divided into subrectangular, thinly sclerotized anterior section, bearing short setae; posterior cercus broadly sclerotized medially, with apical row of peg-like setae on either side of distinct median notch. Epandrium small, oval; lamellae separated dorsally beneath cercus by wide membranous gap. Surstylus short, broad and

truncate apically, clothed in fine setae only. Hypandrium keel-like, prolonged dorsally into phallic guide; gonocoxal apodeme small, rounded; apex of hypandrium flattened and broad surrounding emerging phallus; postgonites appear fused to apex of hypandrium. Phallus strongly arched at base, tapered to slender recurved tip; ejaculatory apodeme small, apical margin expanded.

Female. Similar to male except as follows: stout setae on fore and midlegs longer and more pronounced. T10 divided medially. Cercus short and rounded apically, slightly longer than width, shorter than length of tergite 10.

Distribution. This species is restricted to Tasmania (Fig. 21), currently known only from the type-locality and apparently active in cold months, from May to September [minimum temperature: July 3.2°C (Driessen *et al.*, 2013)].

Etymology. The specific name is derived from the Greek *apteros* (wingless), referring to the virtual absence of wings in this species.

Remarks. All specimens were collected in pitfall traps set out in buttongrass moorland (Fig. 2), which at this location has a shrubby element (Myrtaceae, Epacridaceae) as well as monocots (Cyperaceae and Restionaceae) dominated by buttongrass (Driessen *et al.*, 2013). The habitat at approximately 320 m includes many standing pools and riddled with water-filled crayfish burrows (Driessen, pers. comm., 2014). Small streams run through the plains and large lakes occur nearby. In addition, the waters are highly acidic (around pH 4). A montane moorland site (Lake St. Clair, approx. 800 m) was also surveyed by Driessen *et al.* (2013), but these flightless empidids were not collected.

Wingless or flightlessness among Empidoidea is possibly an adaptation for increased running ability among secretive habitats such as the grasses of the moorland and/or an adaptation to cold conditions which make thermoregulation of thoracic flight muscles difficult (Hackman, 1964; Bickel, 2006). Included among the pitfall trap samples from McPartlan Pass was another wingless empidoid, *Apterodromia tasmanica* Sinclair & Cumming (Hybotidae: Ocydromiinae). This latter species was originally known from litter samples, collected in January and March (Sinclair & Cumming, 2000). Ground predation, particularly from ants has been cited as a major factor limiting wider development of flightlessness in Diptera (Bickel, 2006). However, ant abundance was only lower during the cold months compared to warm months at this lowland moorland (Driessen *et al.*, 2013, fig. 1).

Hydropeza cornuta sp. nov.

Figs 8, 11

Type material. Holotype ♂, labelled: "AUST: N.QLD:/ 31.6km/ up Mt. Lewis Rd., 1000m/ 21.iv.1994, cascading/ creek, B. J. Sinclair/ 16°30'S 145°17'E"; "HOLOTYPE/ *Hydropeza/ cornuta/* Sinclair [red label]" (AMS). Paratypes: **Queensland:** 1♂, 14.7 km up Mt. Lewis Rd., 860 m, 22.iv.1994, cascading ck, 16°30'S 145°17'E, B. J. Sinclair (CNC); 1♂, 25 km up Mt. Lewis Rd., 1000 m, 22.iv.1994, roadside pools, 16°32'S 145°17'E, B. J. Sinclair (CNC); 7♂♂, 31.6 km up Mt. Lewis Rd., 1000 m, 21.iv.1994, cascading ck, 16°30'S 145°17'E, B. J. Sinclair (AMS, CNC).

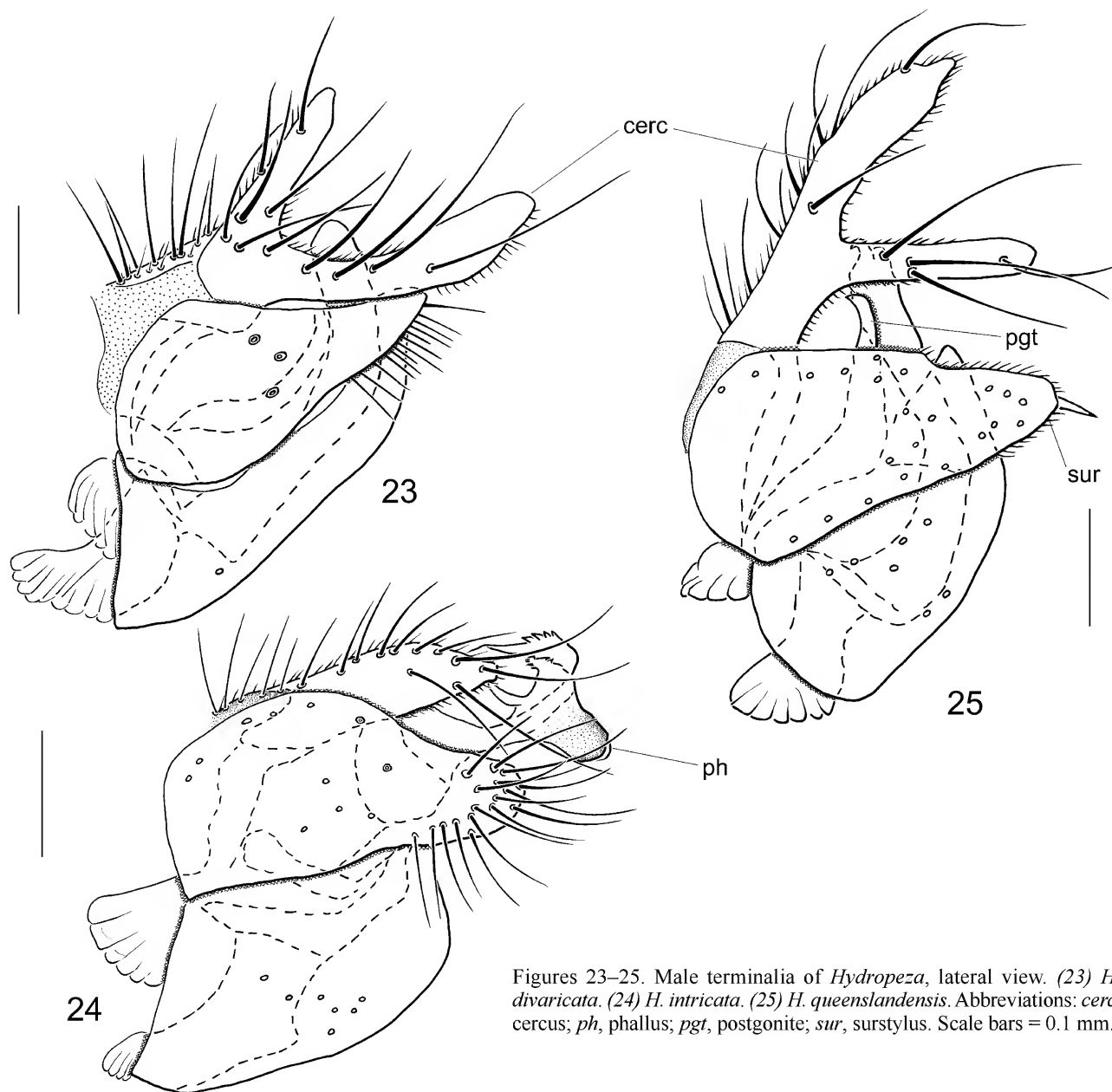
Diagnosis. This species is distinguished from other Queensland species by acrostichal setae confined anteriorly of an imaginary line connecting the first (anteriormost) dorsocentral setae; male scutellum with at most 1–2 pairs of elongate discal setae; male mid femur with short row of basal posteroventral setae and mid tibia with short row of spine-like setae on apical third; male hind trochanter with spine-like anteroventral seta; and male cercus long, projecting and antler-like.

Description. Head and abdomen dark brown, thorax brown with paler patches; coxae brownish yellow, legs progressively darker towards tips. Wing length 2.6–3 mm.

Male. Head. Ocellar setae very long, erect, divergent, inserted posterior to anterior ocellus; ocellar tubercle with some long setulae; postocellar seta stout and dark; upper postocular setae stout and dark, lower setae fine and slender; postgenal setae similar to lower postoculars. Face without setulae. Scape and pedicel slightly paler than postpedicel; scape short and slender, slightly longer than length of globular pedicel; postpedicel not greatly prolonged, more than 3× longer than scape, basal portion elongate-oval, slightly longer than slender, straight apical portion; arista-like stylus distinctly longer than postpedicel, concolorous with postpedicel. Proboscis stout and robust, extended beyond mid-length of fore coxa, directed posteriorly; palpus half-length of proboscis, clothed in long pale and dark setae; apex of palpus rounded; apical third of palpus somewhat flattened with dense pubescence.

Thorax. Clothed in fine pruinescence; mesonotum brown, with postpronotal lobe, lateral margin and postalar ridge pale brown; pleura paler than notum, pale along sutures. Setae generally long and stout; 2–3 acrostichal setulae confined anterior to 1st dorsocentral seta, less than 0.5× length of dc; pprn with 1 seta and several short setulae; 1 long presut spal; 5–6 uniserial dc, about subequal in length; 3 npl; 1 long psut spal and 1–2 finer setae; 1 pal seta; 1 pair of sctl, with 1–2 pairs of finer outer marginal setae; disc of scutellum with 1–2 pairs of long setae. Anteprepronotum with pair of pale setulae.

Legs. Coxae and femora ventrally yellowish-brown; remaining segments increasingly darker apically. Inner anterior margin of fore coxa with some 15–20 dark variously lengthened and thickened spine-like setae, mostly concentrated apically; basal most seta longer than width of coxa. Anterior surface of mid and hind coxae with long brown setae. Legs clothed in very long setae as typical for genus, especially ventral faces. Fore femur straight, inflated (subequal in thickness to hind femur), with row of 2 stout anterior setae at apical fifth; 5–7 posterodorsal setae, stouter towards apex. Fore tibia with 2 anteroventral setae on apical third; 2 anterodorsal and 2 posterodorsal setae; 1 anterodorsal and 1 ventral preapical seta. Fore tarsomere 1 with 1 basal anteroventral and 1 preapical anteroventral seta, more than 2× width of segment; 1 long basal ventral and 2 shorter ventral setae on basal half. Mid femur with row of 5–6 anterodorsal setae, stouter towards apex; 1 anterior, 1 dorsal and 1 posterior seta on apical third; basal half with row of 4–5 stout posteroventral setae; apex with 1 anterior and 1 posterior preapical seta. Mid tibia with width reduced on ventral apical third, with row of 5 short spine-like setae; apex with short spur-like ventral seta; 1 anterodorsal and 1 posterodorsal seta near mid-length; 1 basal posterodorsal seta; apex with 1 dorsal and 1 posterior seta. Mid tarsomere 1 with 1 long



Figures 23–25. Male terminalia of *Hydropeza*, lateral view. (23) *H. divaricata*. (24) *H. intricata*. (25) *H. queenslandensis*. Abbreviations: cerc, cercus; ph, phallus; pgt, postgonite; sur, surstylus. Scale bars = 0.1 mm.

anteroventral basal seta. Hind femur inflated, subequal in thickness to fore femur, without erect dorsal setae; with anteroventral row of stout setae along entire length; apical fourth with 2 anterodorsal, 1 posterodorsal, 1 anterior and 1 posterior seta. Hind trochanter with spine-like anteroventral seta. Hind tibia with 2 anterodorsal, 1 anteroventral and 4–5 posterodorsal setae; 1 preapical anterodorsal and 1 apical anteroventral seta; apical fourth with dense posterior setae. Hind tarsomere 1 without erect setae. All tarsomeres longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs somewhat pale, flattened and expanded; tarsomere 4 of hindleg not laterally compressed ventrally; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Infusate with 1 long basal costal seta, longer than sc1; all veins lacking setulae; R_4 and R_5 distinctly divergent apically; bm-m complete; cell dm slightly produced, longer than cell bm; CuA + CuP reduced to streak. Halter brown.

Abdomen. Tergites and sternites clothed in setae; setae of posterior margin overlapping more than half length of following tergite. T8 broad, nearly one-half length of T7; posterior marginal setae slender, some twice length of tergite.

Terminalia (Fig. 11). Cercus long, projected and antler-like, deeply forked, U-shaped; apex of upper branch with broad notch and long seta, arched medially, 3× longer than lower branch; lower branch with rounded apex, bearing several long setae. Epandrium broad, tapered apically with long setae in vertical row. Surstylus strongly tapered, apex hook-shaped, strongly arched; posterior margin with row of stout setae. Hypandrium keel-like, not greatly prolonged; apical margin with deep medial notch; gonocoxal apodeme short, rounded; postgonite recurved, sickle-shaped. Phallus elongate, upright, broad, apically flattened and spoon-shaped; ejaculatory apodeme L-shaped, longer than gonocoxal apodeme.

Female. Unknown.

Distribution. This species is recorded from above 800 m on Mt. Lewis, Queensland (Fig. 8).

Etymology. The specific name is from the Latin *cornutus* (bearing horns, horned), in reference to the antler-shaped and upright projecting cerci.

***Hydropeza curvata* sp. nov.**

Figs 8, 12

Type material. Holotype ♂, labelled: "AUST: N.QLD:/ 14.7km/ up Mt. Lewis Rd., 860m/ 22.iv.1994, cascading/ creek, B. J. Sinclair/ 16°30'S 145°17'E"; "HOLOTYPE/ *Hydropeza/ curvata/* Sinclair [red label]" (AMS). Paratypes: **Queensland:** 6♀, same data as holotype, 16, 22.iv.1994 (AMS, CNC); 1♀, 14.7 km up Mt. Lewis Rd., 860 m, 15–16.iv.1994, ypana, stream, 16°30'S 145°17'E, B. J. Sinclair (CNC); 1♂, 1♀, 31.6 km up Mt. Lewis Rd., 1000 m, 21.iv.1994, cascading ck, 16°30'S 145°17'E, B. J. Sinclair (CNC).

Diagnosis. This species is distinguished from other Queensland species by acrostichal setae extending to prescutellar depression; male scutellum with at most a pair of elongate discal setae; male mid femur with short row of basal posteroventral setae and mid tibia with short row of spine-like setae on apical third; male hind trochanter without spine-like anteroventral setae; and male cercus deeply forked, V-shaped. Females are distinguished from all other species by numerous marginal setae on the scutellum and acrostichal setae extending to the prescutellar depression.

Description. Head and abdomen dark brown, thorax brown with paler patches; coxae brownish yellow, legs progressively darker towards tips. Wing length 3.2–3.6 mm.

Male. Head. Ocellar setae very long, erect, divergent, inserted posterior to anterior ocellus; ocellar tubercle with some long setulae; postocellar seta stout and dark; upper postocular setae stout and dark, lower setae fine and slender; postgenal setae similar to lower postoculars. Face without setulae. Scape and pedicel slightly paler than postpedicel; scape short and slender, slightly shorter than length of globular pedicel; postpedicel not greatly prolonged, 2× longer than pedicel, basal portion elongate-oval, longer than slender, straight apical portion; arista-like stylus slightly longer than postpedicel, concolorous with postpedicel. Proboscis stout and robust, extended slightly beyond mid-length of fore coxa, directed posteriorly; palpus about half length of proboscis, clothed in long dark setae; apex of palpus rounded; apical third of palpus flattened with dense pubescence.

Thorax. Clothed in fine pruinescence; mesonotum brown, with postpronotal lobe, lateral margin and postalar ridge pale brown; pleura paler than notum, pale along sutures. Setae generally long and stout; acrostichal setulae extending to prescutellar depression, less than 0.5× length of dc; pprn with 1 seta and several short setulae; 1 long presut spal; 5 uniserial dc, about subequal in length, with 2–3 intermixed nearly subequal setae; 3 npl; 1 long psut spal and 1–2 finer setae; 1 pal seta; 1 pair of sctl, with 2 pairs of finer outer marginal setae; disc of scutellum with 1 pair of long setae. Antepronotum with pair of pale setulae.

Legs. Coxae and femora ventrally yellowish-brown; remaining segments increasingly darker apically. Inner anterior margin of fore coxa with some 15 dark, variously lengthened and thickened spine-like setae, mostly concentrated apically; basal most seta longer than width of coxa. Anterior surface of mid and hind coxae with long brown setae. Legs clothed in very long setae as typical for genus, especially ventral faces. Fore femur straight, inflated

(narrower than hind femur), with row of 2 stout anterior setae at apical fifth; 5–6 posterodorsal setae, stouter towards apex. Fore tibia with 2 anteroventral setae on apical third; 2 anterodorsal and 2 posterodorsal setae; 1 anterodorsal preapical seta. Fore tarsomere 1 with 1 basal anteroventral and 1 preapical anteroventral seta, more than 2× width of segment; 1 long basal ventral and 1 shorter ventral seta on basal third. Mid femur with 2–3 anterodorsal setae, 1 anterior seta and 1 posterodorsal seta on apical third; basal half with row of 3–4 stout posteroventral setae; apex with 1 anterior, 1 dorsal and 1 posterior preapical seta. Mid tibia with width reduced on ventral apical third, with row of 7–8 short spine-like setae; apex with short, spur-like ventral seta; 1 anterodorsal and 1 posterodorsal seta near mid-length; 1 basal posterodorsal seta; apex with 1 dorsal and 1 posterior seta. Mid tarsomere 1 with 1 long anteroventral basal seta. Hind femur inflated, nearly 2× broader than fore femur, without erect dorsal setae; with anteroventral row of stout setae along entire length; apical fourth with 2 anterodorsal, 1 anterior and 1 posterior seta. Hind trochanter without spine-like anteroventral setae. Hind tibia with 2 anterodorsal and 4–6 posterodorsal setae; 1 preapical anterodorsal and 1 apical anteroventral seta; apical fourth with dense posterior setae. Hind tarsomere 1 without erect setae. All tarsomeres longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs somewhat pale, flattened and expanded; tarsomere 4 of hindleg not laterally compressed ventrally; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Infusate with 1 long basal costal seta, longer than sctl; all veins lacking setulae; R₄ and R₅ distinctly divergent apically; bm-m complete; cell dm produced apically, subequal in length to cell bm; CuA + CuP reduced to faint streak. Halter pale brown.

Abdomen. Tergites and sternites clothed in setae; setae of posterior margin overlapping more than half length of following tergite. T8 broad, one-third length of T7; posterior marginal setae slender, less than twice length of tergite.

Terminalia (Fig. 12). Cercus elongate and lying along dorsal edge of epandrium, deeply forked, V-shaped; upper branch slightly twisted, arched medially with narrow apex; lower branch longer than length of upper with broadly rounded apex. Epandrium round, tapered apically. Surstylus thumb-shaped, apex rounded; apical margin with numerous long setae. Hypandrium keel-like, not extended beyond surstylus; apical margin truncate without medial notch; gonocoxal apodeme short, rounded; postgonite digitiform, divergent with sharply attenuated apex. Phallus broad, apically flattened and spoon-shaped; ejaculatory apodeme L-shaped, longer than gonocoxal apodeme.

Female. Similar to male except as follows: scutellum with numerous marginal setae; mid femur lacking row of stout posteroventral basal setae; mid tibia not narrowed apically, lacking row of spine-like setae; hind femur not broader than mid femur, lacking anteroventral row of stout setae. Terminalia (not dissected): cercus slightly longer than epiproct, broad with rounded apex.

Distribution. This species is recorded from above 800 m on Mt. Lewis, Queensland (Fig. 8).

Etymology. The specific name is from the Latin *curvatus* (bend, bow, crook), in reference to slightly twisted upper branch of the male cercus.

Hydropeza divaricata sp. nov.

Figs 19, 23

Type material. Holotype ♂, labelled: "AUST: N.QLD:/ Bellenden Ker N.P./ Bartle Frere Tr., 200m/ 12–21.iv.1994, malaise/ B. J. Sinclair/ 17°25'S 145°51'E"; "HOLOTYPE/ *Hydropeza divaricata*/ Sinclair [red label]" (AMS). Paratypes: **Queensland:** 7♂♂, 9♀♀, same data as holotype (AMS); 5♂♂, 3♀♀, 4 km up Mt. Edith Rd, 800 m, Danbulla St. For., MT across ck, 22–27.iv.1994, 17°05'S 145°38'E, B. J. Sinclair (CNC); 3♂♂, 2♀♀, Mt. Hypipamee NP, 960 m, Barron R., 27.iv.1994, 17°26'S 145°29'E, B. J. Sinclair (CNC).

Diagnosis. This species is distinguished from other Queensland species by acrostichal setae extending posterior to (level of) second dorsocentral setae; male scutellum with at most a pair of elongate discal setae; male mid femur with short row of basal posteroventral setae and mid tibia with short row of spine-like setae on apical third; male hind trochanter without spine-like anteroventral setae; and male cercus deeply forked, U-shaped. Females are distinguished from all other species by 1–2 pairs of discal setae on the scutellum and acrostichal setae extending posterior to (level of) second dorsocentral setae.

Description. Head and abdomen dark brown, thorax brown with paler patches; coxae brownish yellow, legs progressively darker towards tips. Wing length 3.3–4 mm.

Male. Head. Ocellar setae very long, erect, divergent, inserted posterior to anterior ocellus; ocellar tubercle with some long setulae; postocellar seta stout and dark; upper postocular setae stout and dark, lower setae fine and slender; postgenal setae similar to lower postoculars. Face without setulae. Scape and pedicel slightly paler than postpedicel; scape short and slender, slightly longer than length of globular pedicel; postpedicel not greatly prolonged, 3× longer than scape, basal portion elongate-oval, longer than slender, straight apical portion; arista-like stylus slightly longer than postpedicel, concolorous with postpedicel. Proboscis stout and robust, extended slightly beyond mid-length of fore coxa, directed posteriorly; palpus less than half length of proboscis, clothed in long pale setae; apex of palpus rounded; apical third of palpus somewhat flattened with dense pubescence.

Thorax. Clothed in fine pruinescence; mesonotum brown, with postpronotal lobe, lateral margin and postalar ridge pale brown; pleura paler than notum, pale along sutures. Setae generally long and stout; acrostichal setulae extending between 2nd and 4th dorsocentral seta, less than 0.5× length of dc; pprn with 1 seta and several short setulae; 1 long presut spal; 5 uniserial dc, about subequal in length, with 2–3 intermixed nearly subequal setae; 3 npl; 1 long psut spal and 1–2 finer setae; 1 pal seta; 1 pair of sctl, with 2 pairs of finer outer marginal setae; disc of scutellum with 1 pair of long setae. Antepronotum with pair of pale setulae.

Legs. Coxae and femora ventrally yellowish-brown; remaining segments increasingly darker apically. Inner anterior margin of fore coxa with some 15–20 dark, variously lengthened and thickened spine-like setae, mostly concentrated apically; basal most seta longer than width of coxa. Anterior surface of mid and hind coxae with long brown setae. Legs clothed in very long setae as typical for genus, especially ventral faces. Fore femur straight, inflated (narrower than hind femur), with row of 2 stout anterior setae at apical fifth; 5–6 posterodorsal setae, stouter towards

apex. Fore tibia with 2 anteroventral setae on apical third; 2 anterodorsal and 2 posterodorsal setae; 1 anterodorsal preapical seta. Fore tarsomere 1 with 1 basal anteroventral and 1 preapical anteroventral seta, more than 2× width of segment; 1 long basal ventral and 1 shorter ventral seta on basal third. Mid femur with 2–3 anterodorsal setae, 1 anterior seta and 1 posterodorsal seta on apical third; basal half with row of 4–5 stout posteroventral setae; apex with 1 anterior and 1 posterior preapical seta. Mid tibia with width reduced on ventral apical third, with row of 8 short spine-like setae; apex with short spur-like ventral seta; 1 anterodorsal and 1 posterodorsal seta near mid-length; 1 basal posterodorsal seta; apex with 1 dorsal and 1 posterior seta. Mid tarsomere 1 with 1 long anteroventral basal seta. Hind femur inflated, slightly broader than fore femur, without erect dorsal setae; with anteroventral row of stout setae along entire length; apical fourth with 2 anterodorsal, 1 anterior and 1 posterior seta. Hind trochanter without spine-like anteroventral setae. Hind tibia with 2 anterodorsal and 4–5 posterodorsal setae; 1 preapical anterodorsal and 1 apical anteroventral seta; apical fourth with dense posterior setae. Hind tarsomere 1 without erect setae. All tarsomeres longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs somewhat pale, flattened and expanded; tarsomere 4 of hindleg not laterally compressed ventrally; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Infusate with 1 long basal costal seta, longer than sctl; all veins lacking setulae; R₄ and R₅ distinctly divergent apically; bm-m complete, but weakened proximally; cell dm truncate, subequal in length to cell bm; CuA + CuP reduced to streak. Halter brown.

Abdomen. Tergites and sternites clothed in setae; setae of posterior margin overlapping more than half length of following tergite. T8 broad, one-third length of T7; posterior marginal setae slender, less than twice length of tergite.

Terminalia (Fig. 23). Cercus elongate and lying along dorsal edge of epandrium, deeply forked, U-shaped; apex of upper branch rounded, arched medially; lower branch longer than length of upper. Epandrium narrow, tapered apically. Surstylus weakly differentiated, apex rounded, not prolonged; ventral margin with row of stout setae. Hypandrium keel-like, not greatly prolonged; apical margin truncate without medial notch; gonocoxal apodeme short, rounded; postgonite digitiform, divergent with arched, rounded apex. Phallus broad, apically flattened and spoon-shaped; ejaculatory apodeme L-shaped, longer than gonocoxal apodeme.

Female. Similar to male except as follows: scutellum with 1–2 pairs of discal setae; mid femur lacking row of stout posteroventral basal setae; mid tibia not narrowed apically, lacking row of spine-like setae; hind femur not strongly inflated, lacking anteroventral row of stout setae. Terminalia (not dissected): cercus slightly longer than epiproct, broad with rounded apex.

Distribution. This species is recorded from northern Queensland sites at 200 m and above 800 m (Fig. 19).

Etymology. The specific name is from the Latin *divaricatus* (spread apart, separate, fork), in reference to U-shaped male cercus.

Remarks. A single female specimen was collected at Cape Tribulation (Little Cooper Ck, 75 m, 16°10'S 145°27'E), but a male from this locality is required to confirm its identity.

***Hydropeza intricata* sp. nov.**

Figs 4, 20, 24

Type material. Holotype ♂, labelled: "AUST: N.QLD:/ 14.7km/ up Mt. Lewis Rd., 860m/ 22.iv.1994, cascading/ creek, B. J. Sinclair/ 16°30'S 145°17'E"; "HOLOTYPE/ *Hydropeza/ intricata/ Sinclair* [red label]" (AMS). Paratypes: **Queensland:** 2♂♂, 4♀♀, same data as holotype (AMS); 3♂♂, 1♀, 31.6 km up Mt. Lewis Rd., 1000 m, 21.iv.1994, cascading ck, 16°30'S 145°17'E, B. J. Sinclair (CNC).

Diagnosis. This species is distinguished from other Queensland species by acrostichal setae extending to between first and second dorsocentral setae; male scutellum with 1 pair of elongate discal setae; male mid femur with row of short basal posteroventral setae and mid tibia with short row of spine-like setae on apical third; male hind trochanter with 2 spine-like anteroventral setae; and male cercus unmodified and apex of the phallus is inflated and highly complex. Females are distinguished from all other species by 1 pair of discal setae on the scutellum and segment 8 broad and inflated, not flattened.

Description. Head and abdomen dark brown, thorax brown with paler patches; coxae brownish yellow, legs progressively darker towards tips. Wing length 3–3.3 mm.

Male. Head. Ocellar setae very long, erect, divergent, inserted posterior to anterior ocellus; ocellar tubercle with some long setulae; postocellar seta stout and dark; upper postocular setae stout and dark, lower setae fine and slender; postgenal setae similar to lower postoculars. Face without setulae. Scape and pedicel slightly paler than postpedicel; scape short and slender, slightly longer than length of globular pedicel; postpedicel not greatly prolonged, 3× longer than scape, basal portion elongate-oval, slightly longer than slender, straight apical portion; arista-like stylus distinctly longer than postpedicel, concolorous with postpedicel. Proboscis stout and robust, extended beyond mid-length of fore coxa, directed posteriorly; palpus half-length of proboscis, clothed in long pale and dark setae; apex of palpus rounded; apical third of palpus somewhat flattened with dense pubescence.

Thorax. Clothed in fine pruinescence; mesonotum brown, with postpronotal lobe, lateral margin and postalar ridge pale brown; pleura paler than notum, pale along sutures. Setae generally long and stout; 2–3 acrostichal setulae extending to between 1st and 2nd dorsocentral setae, less than 0.5× length of dc; pprn with 1 seta and several short setulae; 1 long presut spal; 5 uniserial dc, about subequal in length with several setae interspersed; 3 npl; 1 long psut spal and 1–2 finer setae; 1 pal seta; 1 pair of sctl, with 1 pair of finer outer marginal setae; disc of scutellum with 1 pair of long setae. Antepronotum with pair of pale setulae.

Legs. Coxae and femora ventrally yellowish-brown; remaining segments increasingly darker apically. Inner anterior margin of fore coxa with some 15–20 dark, variously lengthened and thickened spine-like setae, mostly concentrated apically; basal most seta longer than width of coxa. Anterior surface of mid and hind coxae with long brown setae. Legs clothed in very long setae as typical for genus, especially ventral faces. Fore femur straight, inflated (subequal in thickness to mid femur), with row of 2 stout anterior setae at apical fifth; 5–7 posterodorsal setae, apical 2 setae distinctly stouter. Fore tibia with 3 anteroventral setae on apical third; 2 anterodorsal and 2 posterodorsal

setae; 1 anterodorsal preapical seta. Fore tarsomere 1 with 1 basal anteroventral and 1 preapical anteroventral seta, more than 2× width of segment; 1 long basal ventral, 2 shorter ventral setae at middle and apex. Mid femur with row of 3–4 anterodorsal setae stouter towards apex; 1 anterior and 1 posterior seta on apical third; basal half with row of 4–5 short, stout posteroventral setae, less than width of femur; apex with 1 anterior, 1 dorsal and 1 posterior preapical seta. Mid tibia with width reduced on ventral apical third, with row of 5–8 short spine-like setae; apex with short spur-like ventral seta; 2 posterodorsal setae; apex with 1 dorsal seta. Mid tarsomere 1 with 1 long anteroventral basal seta. Hind femur inflated, nearly 1.5× broader than fore or mid femora, without erect dorsal setae; with anteroventral row of stout setae along entire length; apical fourth with 2 anterodorsal, 1 posterodorsal, 1 anterior and 1 posterior seta. Hind trochanter with 2 spine-like anteroventral setae. Hind tibia with 2 anterodorsal, 1 anteroventral and 4–5 posterodorsal setae; 1 preapical anterodorsal and 1 apical anteroventral seta; apical fourth with dense posterior setae. Hind tarsomere 1 without erect setae. Fore and mid tarsomeres slightly longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs somewhat pale, flattened and expanded; tarsomere 4 of hindleg not laterally compressed ventrally; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Infusate with 1 long basal costal seta, longer than sctl; all veins lacking setulae; R₄ and R₅ distinctly divergent apically; bm-m complete; cell dm slightly produced, longer than cell bm; CuA + CuP reduced to streak. Halter brown.

Abdomen. Tergites and sternites clothed in setae; setae of posterior margin overlapping more than half length of following tergite. T8 broad, nearly one-half length of T7; posterior marginal setae slender, some twice length of tergite.

Terminalia (Fig. 24). Cercus projected horizontally, shorter than epandrium, not forked or subdivided; apex sharply pointed ventrally. Epandrium broad with scattered setae. Surstylus slightly tapered, apex broadly rounded, not arched medially. Hypandrium subrectangular broad; apical margin shallowly notched; gonocoxal apodeme broad, rounded; postgonite absent. Phallus broad with complex apical half, inflated with 2 pairs of elongate, anteriorly projecting processes; apex of phallus arrowhead-shaped, projecting posteriorly; ejaculatory apodeme L-shaped, longer than gonocoxal apodeme.

Female. Similar to male except as follows: scutellum with 1 pair of discal setae; mid femur lacking row of stout posteroventral basal setae; mid tibia not narrowed apically, lacking row of spine-like setae; hind femur not strongly inflated, lacking anteroventral row of stout setae. Terminalia (not dissected): segment 8 inflated, broad; cercus slightly longer than epiproct, nearly 2× longer than wide; broad with rounded apex.

Distribution. This species is recorded from above 800 m on Mt. Lewis, Queensland (Fig. 20).

Etymology. The specific name is from the Latin *intricatus* (entangled, complicated), in reference to highly complex and unusual apex of the phallus.

Remarks. Female segment 8 is apparently inflated and not flattened as in related species. It is uncertain whether this is an artefact of drying, but other distinguishing features (e.g., acrostichals and scutellar setae) are consistent among specimens.

Hydropeza queenlandensis sp. nov.

Figs 7, 25

Type material. Holotype ♂, labelled: “AUST: N.QLD: 4km/ up Mt. Edith Rd, 800m/ Danbulla S.F., malaise/ tp.across ck. 22–27.iv./ 1994, B. J. Sinclair/ 17°05'S 145°38'E”; “HOLOTYPE/ *Hydropeza/ queenslandensis/* Sinclair [red label]” (AMS). Paratypes: **Queensland:** 2♂♂, 3♀♀, Mt. Hypipamee NP, 960 m, Barron R., 27.iv.1994, 17°26'S 145°29'E, B. J. Sinclair (CNC); 3♂♂, 11♀♀, same data as holotype (AMS); 2♀♀, 14.7 km up Mt. Lewis Rd., 860 m, 22.iv.1994, cascading ck, 16°30'S 145°17'E, B. J. Sinclair (CNC); 11♀♀, 31.6 km up Mt. Lewis Rd., 1000 m, 21.iv.1994, cascading ck, 16°30'S 145°17'E, B. J. Sinclair (AMS, CNC); 5♂♂, 4♀♀, Paluma, Mt. Spec St. For., 3.6 km S Paluma Dam, ck, 29.iv.1994, 800 m, B. J. Sinclair (CNC).

Additional material. Queensland: 2♀♀, Mt. Finnigan, 14.v.1981, MT, D.H. Colless (ANIC).

Diagnosis. This species is distinguished from other Queensland species by restriction of the acrostichal setae anterior to an imaginary line connecting the first (anteriormost) dorsocentral setae; male scutellum with several elongate discal setae; male mid femur with short row of basal posteroventral setae and mid tibia with short row of spine-like setae on apical third; male hind trochanter with single spine-like anteroventral seta; and male cercus deeply forked, Y-shaped. Females are distinguished from all other species by the highly setose scutellum.

Description. Head and abdomen dark brown, thorax brown with paler patches; coxae brownish yellow, legs progressively darker towards tips. Wing length 3.5–4 mm.

Male. *Head.* Ocellar setae very long, erect, divergent, inserted posterior to anterior ocellus; ocellar tubercle with some long setulae; postocellar seta stout and dark; upper postocular setae stout and dark, lower setae fine and slender; postgenal setae similar to lower postoculars. Face without setulae. Scape and pedicel paler than postpedicel; scape short and slender, slightly longer than length of globular pedicel; postpedicel not greatly prolonged, 3× longer than scape, basal portion elongate-oval, longer than slender, straight apical portion; arista-like stylus slightly longer than postpedicel, concolorous with postpedicel. Proboscis stout and robust, extended slightly beyond mid-length of fore coxa, directed posteriorly; palpus less than half-length of proboscis, clothed in long pale setae; apex of palpus rounded; apical third of palpus somewhat flattened with dense pubescence.

Thorax. Clothed in fine pruinescence; mesonotum brown, with postpronotal lobe, lateral margin and postalar ridge pale brown; pleura paler than notum, pale along sutures. Setae generally long and stout; 3–4 acrostichal setulae anterior to 1st dorsocentral seta, less than 0.33× length of dc; pprn with 1 seta and several short setulae; 1 long presut spal; 5 uniserial dc, about subequal in length, without intermixed finer setae; 3 npl; 1 long psut spal and 1–2 finer setae; 1 pal seta; 1 pair of sctl, with 1–2 pairs of finer outer marginal setae; disc of scutellum with several long setae. Anteppronotum without pair of setae.

Legs. Coxae and femora ventrally yellowish-brown; remaining segments increasingly darker apically. Inner anterior margin of fore coxa with some 15 dark, variously lengthened and thickened spine-like setae, mostly concentrated apically;

basal most seta longer than width of coxa. Anterior surface of mid and hind coxae with long brown setae. Legs clothed in very long setae as typical for genus, especially ventral faces. Fore femur straight, slightly inflated, with row of 2 stout anterior setae at apical fifth; 6–8 posterodorsal setae, stouter towards apex. Fore tibia with 2 anteroventral setae on apical third; 2 anterodorsal setae; 1 anterodorsal and 1 ventral preapical seta. Fore tarsomere 1 with 1 basal anteroventral and 1 preapical anteroventral seta, more than 2× width of segment; 1 long basal ventral and 1 shorter ventral seta on basal third. Mid femur with 2–3 anterodorsal setae, 1 anterior seta and 1 posterodorsal seta on apical third; basal half with row of 3–4 stout posteroventral setae; apex with 1 anterior and 1 posterior preapical seta. Mid tibia with width reduced on ventral apical third, with row of 5 short spine-like setae; apex with short spur-like ventral seta; 1 anterior seta at mid-length; apex with 1 anterodorsal and 1 posterodorsal seta. Mid tarsomere 1 with 1 long anteroventral basal seta. Hind femur slightly broader than mid femur, without erect dorsal setae; with anteroventral row of stout setae along entire length; apical fourth with 2 anterodorsal, 1 anterior and 1 posterior seta. Hind trochanter with single spine-like anteroventral seta. Hind tibia with 2 anterodorsal and 4 posterodorsal setae; 1 apical anteroventral seta; apical third with dense posterior setae. Hind tarsomere 1 without erect setae. Tarsomeres of fore and midlegs longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs somewhat pale, flattened and expanded; tarsomere 4 of hindleg not laterally compressed ventrally; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Infusate with 1 long basal costal seta, longer than sctl; all veins lacking setulae; R₄ and R₅ distinctly divergent apically; bm-m complete; cell dm truncate to slightly produced, longer than length of cell bm; CuA + CuP reduced to streak. Halter brown.

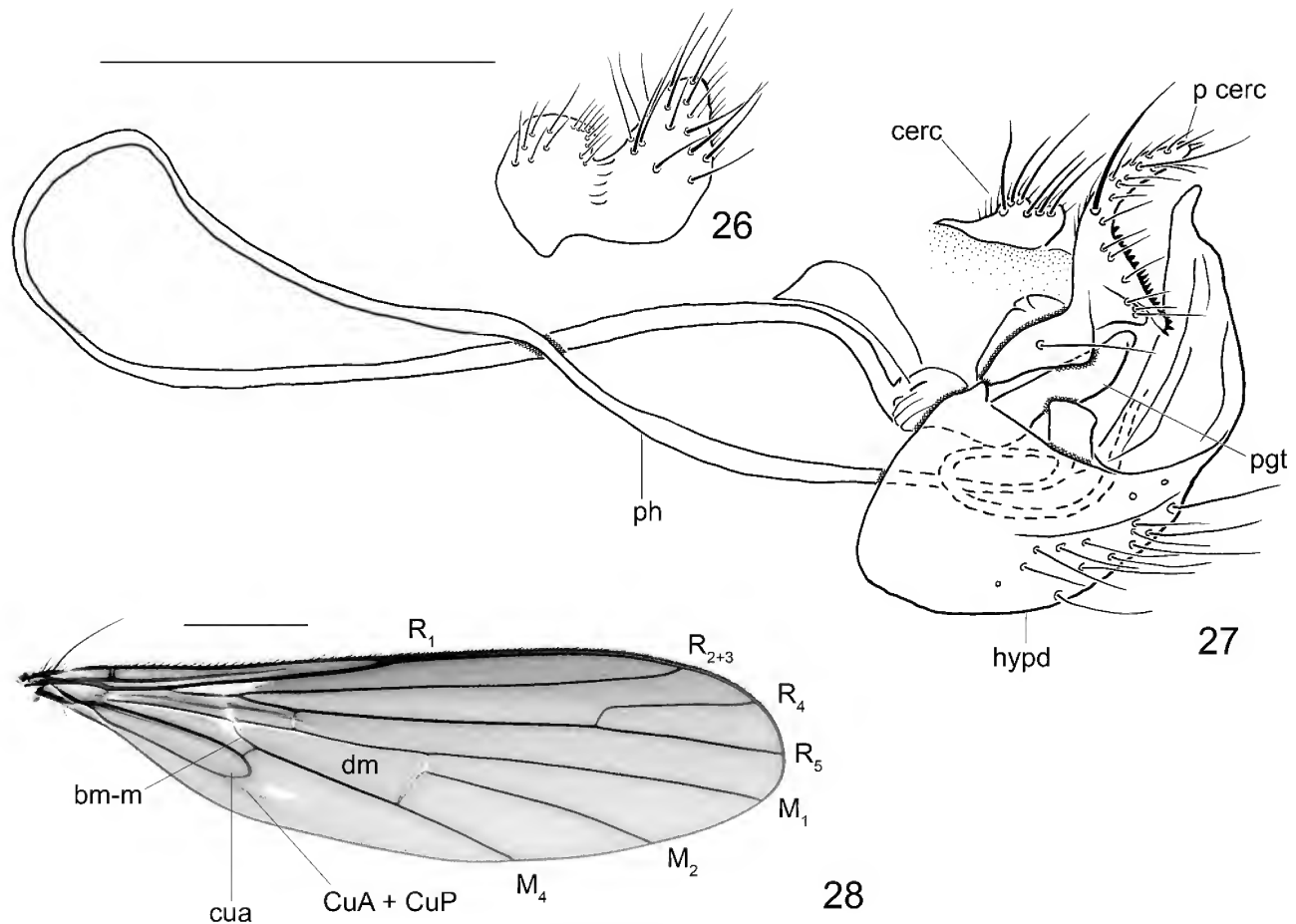
Abdomen. Tergites and sternites clothed in setae; setae of posterior margin overlapping more than half length of following tergite. T8 broad, more than half length of T7; posterior marginal setae slightly shorter than preceding tergites.

Terminalia (Fig. 25). Cercus elongate and projected, deeply forked, Y-shaped; apex of upper branch flattened, with short, sharp projection medially; lower branch subequal in length to upper. Epandrium narrow, tapered apically. Surstylus weakly differentiated, apex prolonged as stout, sharp thorn-like projection. Hypandrium keel-like, not greatly prolonged; apical margin with deep medial notch; gonocoxal apodeme short, rounded; postgonite digitiform, divergent, with hooked apex. Phallus broad, apically flattened and spoon-shaped; ejaculatory apodeme longer than gonocoxal apodeme.

Female. Similar to male except as follows: scutellum highly setose; mid femur lacking row of stout posteroventral basal setae; mid tibia not narrowed apically, lacking row of spine-like setae; hind femur lacking anteroventral row of stout setae. Terminalia (not dissected): cercus slightly longer than epiproct, slender with rounded apex.

Distribution. This species is widespread in the high tablelands in the wet tropics region of northern Queensland (Fig. 7).

Etymology. The specific name refers to the distribution of this species.



Figures 26–28. *Hydropeza tasmanica*. (26) Male epandrium, lateral view. (27) Male terminalia with epandrium removed, lateral view. (28) Wing. Abbreviations: *bm-m*, basal medial crossvein; *cerc*, cercus; *cua*, anterior cubital cell; *CuA + CuP*, anterior branch of cubital vein plus posterior branch of cubital vein; *dm*, discal medial cell; *hypd*, hypandrium; *M*, medial vein; *p cerc*, posterior cercus; *pgt*, postgonite; *ph*, phallus; *R*, radial vein. Scale bars = 0.4 mm, except Fig. 28 where scale bar = 0.1 mm.

Remarks. The two females from Mt. Finnigan were excluded from the type series because the acrostichal setae extend beyond the first dorsocentrals. Collection of male specimens from this locality is required to confirm species identity.

Hydropeza tasmanica sp nov.

Figs 5, 13–17, 22, 26–28

Type material. Holotype ♂, labelled: “AUST:TAS: Cradle/ Mtn N.P., Pencil Pine/Tr., 20.ii.1994/ Pencil Pine Ck., 800m/B. J. Sinclair”; “HOLOTYPE/ *Hydropeza tasmanica*/ Sinclair [red label]” (AMS). Paratypes: **Tasmania**: 1♀, nr. Collingwood Ck on Lyell Hwy, 27.i.1989, buttongrass/ heath, ypan, D. Bickel (AMS); 3♂♂, 5♀♀, Collins Cap, W Mt. Wellington, 800 m, 18.ii.1961, L. Couchman (ANIC); 2♂♂, 2♀♀, Cradle Mtn NP, Pencil Pine Tr., 20.ii.1994, Pencil Pine Ck, 800 m, B. J. Sinclair (CNC); 1♂, Cradle Mtn NP, Overland/ Dove Lake Tr., 21.ii.1994, 800–1000 m, B. J. Sinclair (CNC); 1♂, 3♀♀, Ferntree Gully, ii.1928, I. Smith (ANIC); 1♂, 2♀♀, 8 mi E Gormanston, 28.i.1948, Key, Carne & Kerr (ANIC); 1♂, 1♀, Hartz Mont., 10.xii.1922, A. Tonnoir (ANIC); 1♀, Huon-Picton River junction, 18.ii.1967, A. Neboiss (NMV); 1♂, King River, 4.ii.1923, A. Tonnoir (ANIC); 1♀, 5 mi. W King William Saddle, 4.xi.1961, N. Dobrotworsky (AMS); 7♂♂, 7♀♀, Lyell

Hwy Franklin/Gordon Wild Rivers NP, 19.ii.1994, Franklin R., B. J. Sinclair (CNC); 3♂♂, 2♀♀, Mt. Barrow St. Res., 22.ii.1994, B. J. Sinclair (CNC); 3♂♂, 2♀♀, Mt. Field, 19.xii.1922, A. Tonnoir (ANIC); 1♂, Mt. Field, 11.xi.1953, S. Butler (NMV); 5♂♂, 3♀♀, Mt. Field NP, Lake Dobson, small stream inflow, 18.ii.1994, 1020 m, B. J. Sinclair (CNC); 1♂, 1♀, Mt. Field NP, Mawson Plateau, 1200 m, alpine sweeping, 25.i.1989, D. Bickel (AMS); 2♀♀, Mt. Rufus, 27.i.1948, Key, Carne & Kerr (ANIC); 2♂♂, 1♀, Myrtle Forest, 29.i.1937, G.&C. Davis (ANIC); 2♂♂, 19♀♀, Pelion Hut, 3 kmS Mt. Oakleigh, 41°50'S 146°03'E, 860 m, vi.x.1990, 8.i.–12.ii., 9.iv.–6.vi.1991, D. Naumann (AMS, ANIC); 1♂, 6♀♀, Pelion Hut, 8.i.1991, Nielsen, Edwards (AMS); 1♀, Pelion Plain 1 kmS, 7.vi.1990 (AMS); 1♂, 4♀♀, Scott Peak, Dam Rd. & Clear Ck, 4–5.ii.1989, wet scler, MT, D. Bickel (AMS).

Diagnosis. This is the largest Australian species of *Hydropeza*, distinguished by its dark brown coloration, knob-like ventral process on the male mid femur and slender hind femur.

Description. Head and abdomen dark brown, thorax brown with paler patches; coxae often pale brown, legs progressively darker towards tips. Wing length 6–7.2 mm.

Male. *Head* (Fig. 13). Ocellar setae very long, erect, divergent, inserted posterior to anterior ocellus; ocellar

tubercle with some long setulae; postocellar and postocular setae stout and dark; postgenal setae similar to postoculars. Lower half of face with row of long setulae on inner margin of eye. Scape long and slender, about $2\times$ length of globular pedicel; postpedicel elongate, basal portion onion-shaped, shorter than slender, straight apical portion; arista-like stylus slightly longer than apical portion of postpedicel, concolorous with postpedicel. Proboscis stout and robust, long, extended well beyond mid-length of fore coxa, directed posteriorly; palpus about $0.75\times$ length of proboscis, clothed in long dark setae, some dorsolateral setae stout; apex of palpus pointed; apical third of palpus flattened with dense pubescence.

Thorax. Clothed in fine pruinescence; mesonotum brown, with postpronotal lobe and base of transverse suture pale brown; pleura paler than notum, with dark patches; pale along sutures. Setae generally long and stout; 3–4 acrostichal setulae anterior to 1st dorsocentral seta, about $0.33\times$ length of dc; pprn with 1 seta and several dark, short setulae; 1 long presut spal and 1–2 finer short setae; 5 uniserial dc, about subequal in length, with intermixed finer setae; 3 npl; 1 long psut spal and 1–2 finer setae; 1 pal seta; 1 pair of sctl, with 1–2 pairs of finer outer marginal setae. Antepnotum with pair of long stout setae.

Legs. Brown, increasingly darker apically. Inner anterior margin of fore coxa with more than 20 dark variously lengthened and thickened spine-like setae, mostly concentrated apically and mid-basally; basal most seta longer than width of coxa (Fig. 14). Anterior surface of mid and hind coxae with long brown setae. Legs clothed in very long setae as typical for genus, especially ventral faces. Fore femur slightly arched, with row of 6 anterior setae, apical fifth with 2 longer and stouter anterior setae, longer than width of femur; 4–5 posterodorsal setae and 1 posterior seta at basal third; 1 long preapical posterior seta. Fore tibia with 4 anteroventral, 4 anterodorsal, 4 posteroventral and 4 posterior setae; apical fifth with 1 dorsal and 2 posterodorsal setae; 1 anteroventral and 1 anterodorsal preapical seta. Fore tarsomere 1 with 1 dorsal and 1 anterodorsal near mid-length; 1 ventral seta on basal fourth; apex with 1 anterodorsal and 1 posterodorsal seta. Mid femur with knob-like process at basal third, bearing several short spine-like setae (Fig. 15); 2 long stout setae proximal to process, longer than width of femur (Fig. 16); 3 anterodorsal and 3 posterodorsal setae on distal half; apex with 1 anterodorsal and 1 posterodorsal preapical seta. Mid tibia with anteroventral notch on apical sixth, with distal row of short spine-like setae terminating in pair of claw-like apical setae (Fig. 16); opposite notch with sinuous spur-like anterodorsal seta; 2 anterodorsal setae, 4 posterodorsal setae and 2 anterior setae. Mid tarsomere 1 with ventral curve at base, with long anterior seta; 1 anterodorsal, 1 posterodorsal seta; apex with several preapical stout setae. Hind femur with erect dorsal setae; 1 preapical anterior, 2 preapical anterodorsal and 1 preapical posterodorsal setae on apical fourth, longer than width of femur. Hind tibia with 4–5 anterodorsal and posterodorsal setae; 2 preapical anterior setae; 1 anteroventral seta on apical third. Hind tarsomere 1 with several dorsal and preapical setae. Tarsomeres of fore and midlegs much longer than tibia; ventral apical margin of tarsomere 4 of fore and midlegs somewhat pale, flattened and expanded; tarsomere 4 of hindleg laterally compressed ventrally, keel-like, extending beyond apex; tarsomere 5 of each leg lacking dorsoapical extension (Fig. 17).

Wing (Fig. 28). Infusate with 1 long basal costal seta, longer than sctl; all veins lacking setulae; R_4 and R_5 distinctly divergent apically, base of R_4 often weakened; bm-m complete; cell dm truncate to slightly produced, longer than length of cell bm; CuA + CuP present only as short streak. Halter brown.

Abdomen. Tergites and sternites clothed in setae; setae of posterior margin overlapping more than half length of following tergite. T8 broad, more than half length of T7; posterior marginal setae greatly reduced in length compared to preceding tergites.

Terminalia (Figs 26, 27). Cercus divided into two components: anterior cercus small, thinly sclerotized sclerite surrounding anus, bearing long setae; posterior cercus sickle-shaped, heavily sclerotized with peg-like setae along posteromedial margin; apex of posterior cercus tapered, bearing stout terminal seta. Epandrium small, bilobed with longer setae of posterior lobe; lamellae separated dorsally beneath cercus by wide membranous gap; epandrium not prolonged posteriorly. Surstylus not differentiated. Hypandrium keel-like, prolonged dorsally into phallic guide; gonocoxal apodeme inconspicuous; long setae on posterior half extending to base of dorsal extension; postgonite finger-like, slightly curved. Phallus long and filamentous, extending anteriorly into abdomen for 2–3 segments, twisted into figure-8, emerging from phallic guide of hypandrium; ejaculatory apodeme reduced not plate-like.

Female. Similar to male except as follows: mid femur and tibia lacking modified setae and processes. Terminalia (not dissected): cercus long and slender with rounded apex.

Distribution. This species is restricted to Tasmania (Fig. 22), occurring in upland streams and rivers from western, northeastern and southern Tasmania.

Etymology. The specific name refers to the distribution of this species, which is widespread in Tasmania.

Remarks. The shape of the hypandrium and epandrium is very similar to *H. wardi* Sinclair & McLellan from New Zealand.

Hydropeza unguicula sp. nov.

Figs 6, 18, 21

Type material. Holotype ♂, Tasmania: “Pelion Tas/ June 1990/ INaumann”; “HOLOTYPE/ Hydropeza/ unguicula/ Sinclair [red label]” (ANIC).

Diagnosis. This Tasmanian species is recognized by the modified male forelegs, especially the claw-like process of tarsomere 1 and pointed spatulate process of tarsomere 4 of the male midleg.

Description. Head, thorax and legs dark brown, abdomen slightly paler. Wing length 3.8 mm.

Male. Head. Ocellar setae long, erect, divergent, inserted between anterior and posterior ocelli; ocellar tubercle with several short setulae; postocellar and postocular setae dark, stout to slender; postgenal setae similar to postoculars. Lower half of face lacking setulae. Scape long and slender, about $2\times$ length of globular pedicel; postpedicel elongate, basal portion not broader than pedicel, shorter than slender, tapered apical portion; stylus slightly longer than apical portion of

postpedicel, concolorous with postpedicel. Proboscis stout and robust, long, extended well beyond mid-length of fore coxa, directed posteriorly; palpus about $0.75\times$ length of proboscis, clothed in long setae, apex of palpus rounded (view of apex obscured by wing).

Thorax. Clothed in fine pruinescence; mesonotum brown; pleura paler along sutures. Setae not distinctly long or stout; 6 acrostichal setulae anterior to 1st dorsocentral seta, about $0.25\times$ length of dc; pprn with 1 seta and one dark setula; 1 long presut spal and several finer short setulae; 5 uniserial dc, with intermixed finer setae; 3 npl; 1 long psut spal and 1–2 finer setulae; 1 pal seta; 1 pair of sctl, with 1 pair of finer outer marginal setae. Antepnotum with pair of slender setae.

Legs. Brown, increasingly darker apically. Inner anterior margin of fore coxa with more than 20 dark, short and thickened spine-like setae, mostly concentrated apically and mid-basally; apical setae longer than basal setae of coxa. Anterior surface of mid and hind coxae with long brown setae. Legs not clothed in very long setae as typical for genus. Fore femur slightly arched with long, silky ventral setae; nearly subequal to width of femur; base with pair of long, slender setae, nearly twice width of femur; distal half with distinctly separated brush of long, dark posterodorsal setae. Fore tibia slightly arched medially; posterior face with long, scattered setae, similar to fore femur; apical half with numerous, scattered, spine-like anterodorsal setae; apical half with 2 widely spaced, posteroventral spine-like setae. Fore tarsomere 1 shorter than segment 2, with long claw-like apical process directed ventrally (Fig. 18); base with spine-like anteroventral seta, two-thirds length of tarsomere; apex with spine-like posteroventral, posterior and anteroventral preapical seta; claw-like process tapered and twisted to posterior face of tarsi, bearing 4 long divergent setae, longer than tarsomeres 1 and 2 combined and several stout subapical setae. Fore tarsomere 2 with 1 long radiating seta similar to long setae on claw-like process; with several stout preapical setae. Mid femur with posteroventral row of widely spaced setae, length nearly twice width of femur; basal half with 3 long ventral setae, twice width of femur; 1 anterodorsal on distal fifth; apex with 1 anterodorsal preapical seta. Mid tibia with 2 anterodorsal, 3 anteroventral and row of posteroventral setae; apex with several preapical setae. Mid tarsomere 1 lacking erect stout setae. Hind femur with 1 anterodorsal setae on apical fifth and 1 preapical anterodorsal seta. Hind tibia with 2 anterodorsal setae, 2 anteroventral setae and 1 dorsal seta on apical fourth; 1 anterodorsal and 1 anteroventral preapical seta. Hind tarsomere lacking erect stout setae. Tarsomeres of foreleg longer than tibia; ventral apical margin of tarsomere 4 of foreleg flattened and expanded; midleg tarsomere 4 expanded into pointed spatulate projection, longer than segment; tarsomere 4 of hindleg laterally compressed ventrally, keel-like, extending slightly beyond apex; tarsomere 5 of each leg lacking dorsoapical extension.

Wing. Infusate with 1 long basal costal seta, slightly longer than sctl; all veins lacking setulae; R_4 and R_5 distinctly divergent apically; bm-m complete; cell dm slightly produced, shorter than length of cell bm; CuA + CuP absent. Halter brown.

Abdomen. Tergites and sternites clothed in setae; setae of posterior margin overlapping more than half length of following tergite.

Terminalia (undissected). Cercus divided into small, flat, horizontal dorsal lamellae surrounding anus, and slender,

parallel-sided, medially arched lateral lamellae. Epandrium similar in form to lateral cercal lamella, arched medially. Hypandrium cone-shaped; postgonite not observed. Paired spine-like lobes arching from near base of phallus; phallus long and filamentous, recurved above terminalia.

Female. Unknown.

Distribution. Only the male holotype of this species is known, collected during winter (June) from Cradle Mountain National Park, Tasmania (Fig. 21).

Etymology. The specific name is from the Latin *unguiculus* (claw, talon), in reference to the claw-like projection from tarsomere 1 of the male foreleg.

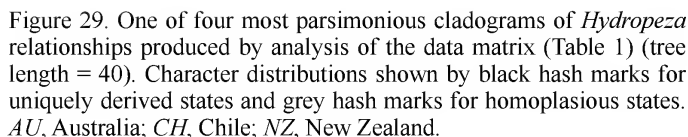
Remarks. The male terminalia was not dissected, because only a single specimen is known. However, the highly modified forelegs should facilitate species recognition.

Discussion

The cladistics analysis resulted in four equally parsimonious trees, with length = 40, CI (consistency index) = 0.6; CI excluding uninformative characters = 0.53, RI (retention index) = 0.73, and RC (rescaled consistency index) = 0.44. The trees differed in the position of the Chilean species, *H. curicoa* Sinclair & Plant, as sister group to the Queensland species or sister to *H. tasmanica* + *H. wardi* group and the arrangement of the species in the Queensland group. In the strict consensus tree, the *H. curicoa* branch is collapsed forming a trichotomy with the Queensland species group and the *H. tasmanica* + *H. wardi* group. One of the four trees was chosen as representative and used to trace the character distributions (Fig. 29).

In the present analysis the New Zealand species are no longer grouped into two clades as reported by Sinclair & McLellan (2004). *Hydropeza aptera* and *H. unguicula* are sisters to the remaining species, but this could be an artefact due to the effects of wing loss in the former and the unknown details of the male terminalia in the latter. In contrast, the *H. longipennae* group (which includes *H. milleri*) was sister to the remaining species of *Hydropeza* in the earlier analysis (Sinclair & McLellan, 2004). *Hydropeza akatarawa* is no longer assigned to the *H. clarae* group due to differences in leg chaetotaxy and complete bm-m crossvein. Three New Zealand species form a monophyletic group on the basis of an incomplete bm-m crossvein (character 9.1). *Hydropeza tasmanica* and *H. wardi* form a monophyletic group united on the basis of peg-like setae on the posterior cercus (character 19.1) and prolongation of the hypandrium (character 20.1). *Hydropeza curicoa* is sister to the Queensland species group (*H. divaricata*, *H. angulata*, *H. intricata*, *H. cornuta*, *H. queenslandensis*) on the basis of the forked posterior cercus (character 21.1) and articulated postgonite (character 22.2). The monophyly of the clade comprising the six species from Queensland is supported by presence of an inflated hind femur (character 13.1).

Transantarctic relationships have been documented in several lineages of Empidoidea (Daugeron *et al.*, 2009; Sinclair, 2010). Within *Hydropeza*, both New Zealand + Australia and Australia + southern South America faunal connections are illustrated. These phylogenetic patterns are consistent with the belief that *Hydropeza* was well distributed

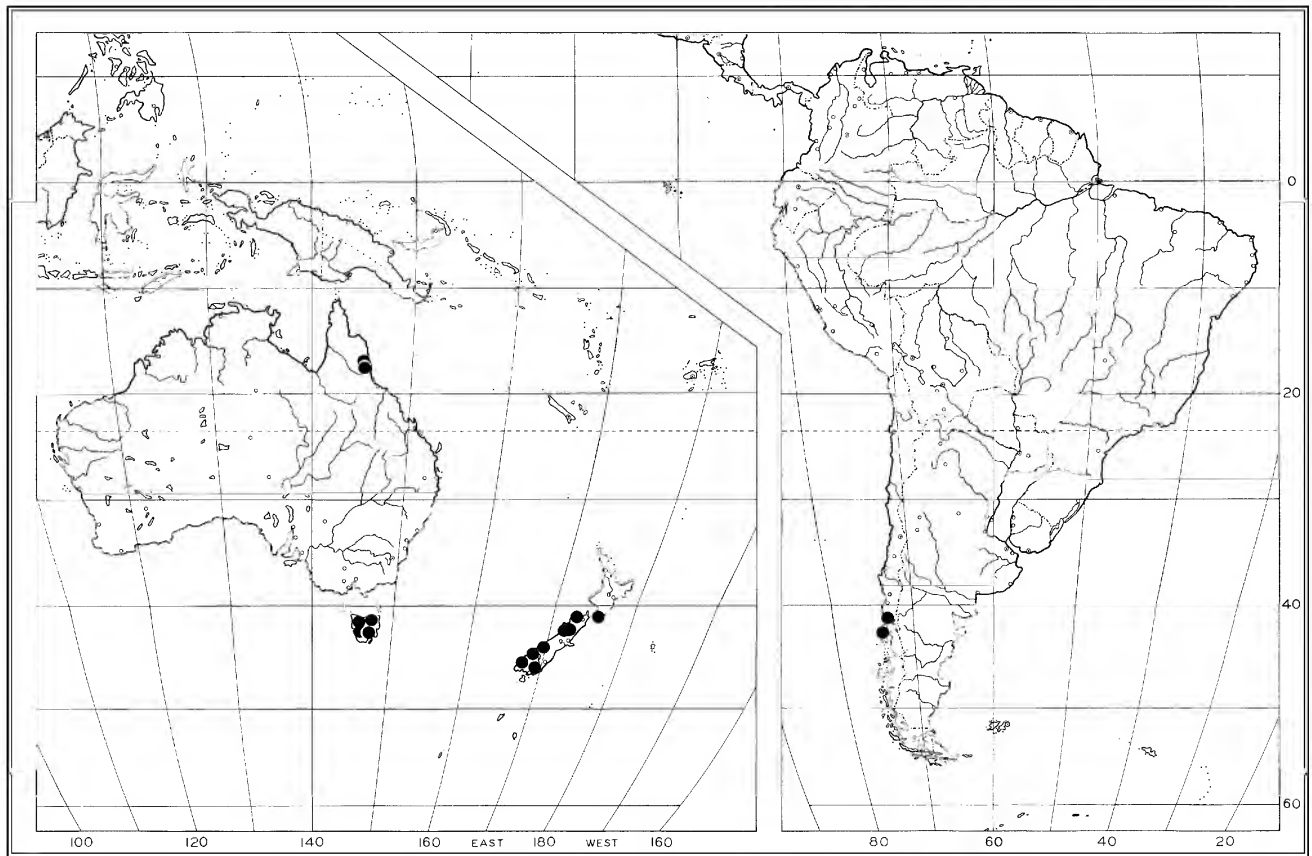


In Australia, *Hydropeza* is presently known only from Tasmania and northern Queensland (Wet Tropics) (Fig. 30). A similar widely disjunct distribution is also recorded for the genus *Apterodromia* Oldroyd (Hybotidae), although also recorded from Western Australia (Sinclair & Cumming, 2000). The aquatic fly fauna of eastern Australia is generally well surveyed using a variety of trapping methods and the disjunct distribution of the genus is possibly not an artefact due to lack of collecting. The absence of the genus from Victoria, New South Wales and southeastern Queensland cannot be explained, especially since a wide range of habitats that are suitable to *Hydropeza* are present in this region. Sampling surface flies with dip nets may produce additional samples from these other regions.

It is rather remarkable that there are five variously sympatric species on Mt. Lewis above 700 m, while only six species are known from the entire Wet Tropics. However, the specimens are all mostly from a single collecting trip, and concentrated efforts elsewhere in this region will likely expand species ranges. High endemism was also found among flightless insects in the Carbine Uplands, which includes Mt. Lewis (Yeates *et al.*, 2002).

Table 1. Data matrix for *Hydropeza*, listing 17 terminal taxa and 22 characters used in the analysis. See Table 2 for character descriptions. Character states were scored 0–3, en-dash for inapplicable data and ? for unknown data.

Taxa	Characters			
	0000000001	1111111112	22	
	1234567890	1234567890	12	
<i>Hydropeza akatarawa</i>	0101011100	0000011200	00	
<i>H. angulata</i>	0001111101	1110110200	03	
<i>H. aptera</i>	000111---0	0000000210	00	
<i>H. clarae</i>	0001001110	1100110200	01	
<i>H. cornuta</i>	0001111101	1111110200	12	
<i>H. curicoa</i>	0011011101	1100110200	12	
<i>H. curvata</i>	0001111101	1110110200	12	
<i>H. divaricata</i>	0001111101	1110110200	12	
<i>H. intricata</i>	0001111101	1111110200	03	
<i>H. milleri</i>	1001001100	1100000100	00	
<i>H. paniculata</i>	0001011110	1100111200	01	
<i>H. queenslandensis</i>	0001111101	0011110200	12	
<i>H. tasmanica</i>	0011011101	1100110211	01	
<i>H. unguicula</i>	0001111100	0000110200	0?	
<i>H. vockerothi</i>	0001011110	0100111200	01	
<i>H. wardi</i>	0011001111	1100110211	01	
<i>Hormopeza</i>	0000100000	0000000000	00	

Figure 30. Known overall distribution of *Hydropeza* (●); large cities (○).**Table 2.** Characters used in the analysis of *Hydropeza*.

- | | |
|----|--|
| 1 | <i>Body colouration:</i> brown to black (0); clothed in distinct blue pruinescence (1) |
| 2 | <i>Postpedicel:</i> with apical stylus (0); lacking apical stylus (1) |
| 3 | <i>Face:</i> bare (0); setose (1) |
| 4 | <i>Prosternum:</i> separate (0); fused to proepisternum (1) |
| 5 | <i>Anteprepronotum:</i> with pair of setae (0); setae greatly reduced, slender or absent (1) |
| 6 | <i>Acrostichals:</i> full length of scutum (0); absent or greatly reduced (1) |
| 7 | <i>Stigma:</i> present (0); absent (1) |
| 8 | <i>Subcosta:</i> complete (0); incomplete (1) |
| 9 | <i>bm-m:</i> complete (0); abruptly terminated, incomplete (1) |
| 10 | <i>Male mid femur:</i> posteroventral row of setae absent (0); posteroventral row of setae at base (1) |
| 11 | <i>Male mid tibia:</i> row of setae absent (0); row of spine-like ventral setae on apical third (1) |
| 12 | <i>Male mid tibia:</i> apical spur-like seta absent (0); apical spur-like seta present (1) |
| 13 | <i>Male hind femur:</i> slender (0); inflated, broader than fore and mid femora (1) |
| 14 | <i>Male hind trochanter:</i> lacking spines (0); 1–2 spine-like setae present (1) |
| 15 | <i>Male tarsomere 4 of fore- and midlegs:</i> unmodified (0); apex flattened and expanded (1) |
| 16 | <i>Tarsomere 4 of hindleg:</i> unmodified (0); keel-shaped (1) |
| 17 | <i>Tarsomere 5 extension:</i> absent (0); present (1) |
| 18 | <i>Epandrial lamellae:</i> not separated (0); narrowly and weakly connected (1); distinctly separated (2) |
| 19 | <i>Posterior cercus:</i> lacking brush of setae (0); brush of short, peg-like setae (1) |
| 20 | <i>Hypandrium:</i> without prolongation (0); prolonged into tapered phallic guide (1) |
| 21 | <i>Cercus shape:</i> unbranched (0); posterior section forked (1) |
| 22 | <i>Postgonites:</i> appressed or fused to phallus (0); short, finger-like (1); articulated (2); arched medially to opposite pgd and appressed or fused (3) |

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First Records of the Invasive “Upside-down Jellyfish”, *Cassiopea* (Cnidaria: Scyphozoa: Rhizostomeae: Cassiopeidae), from Coastal Lakes of New South Wales, Australia

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ABSTRACT. Scyphozoans of the genus *Cassiopea* (Cassiopeidae) are notable for their unusual benthic habit of lying upside-down with tentacles facing upwards, resulting in their common name, “upside-down jellyfish”. In Australia, five named species of *Cassiopea* have been recorded from the tropical north. *Cassiopea* are frequently noted worldwide as invasive species and here, we report the first records of the genus and family from temperate eastern Australia on the basis of specimens collected from two widely separated coastal lakes, Wallis Lake and Lake Illawarra; these specimens represent southern range extensions of the genus by approximately 600 km and 900 km, respectively. *Cassiopea* from Lake Illawarra and Wallis Lake appear to represent different species, which we assign to *C. ndrosia* and *C. cf. maremetens*, respectively, noting morphological discrepancies from published accounts.

KEYWORDS. Introduced species, coastal lake, *Cassiopea*, Wallis Lake, Lake Illawarra, New South Wales

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The medusa stage of the scyphozoan, *Cassiopea* (Cassiopeidae), is a distinctive marine or estuarine jellyfish, notable for its unusual, inverted, largely sedentary and benthic behaviour, imparting the common name “upside-down jellyfish”. This lifestyle typically involves the jellyfish lying in sheltered, shallow water with the aboral surface of the exumbrella facing downward onto sediments and the oral arms above. This posture and niche provides sunlight to algal endosymbionts (zooxanthellae) within the tissues although the jellyfish are also suspension feeding carnivores (Verde & McCloskey, 1998; Schembri *et al.*, 2009; Marsh &

Slack-Smith, 2010). The severity of stings to humans from *Cassiopea* has been variably reported from mild or absent to severe (Southcott, 1982; Marsh & Slack-Smith, 2010).

Although *Cassiopea* is readily recognized, the species level taxonomy is confused and requires reappraisal (Holland *et al.*, 2004). Worldwide, at least 11 species are currently recognized: *Cassiopea andromeda* (Forskål, 1775), *C. depressa* Haeckel, 1880, *C. frondosa* (Pallas, 1774), *C. medusa* Light, 1914, *C. maremetens* Gershwin, Zeidler & Davie, 2010, *C. mertensi* Brandt, 1838, *C. ndrosia* Agassiz & Mayer, 1899, *C. ornata* Haeckel, 1880, *C. xamachana*

* author for correspondence

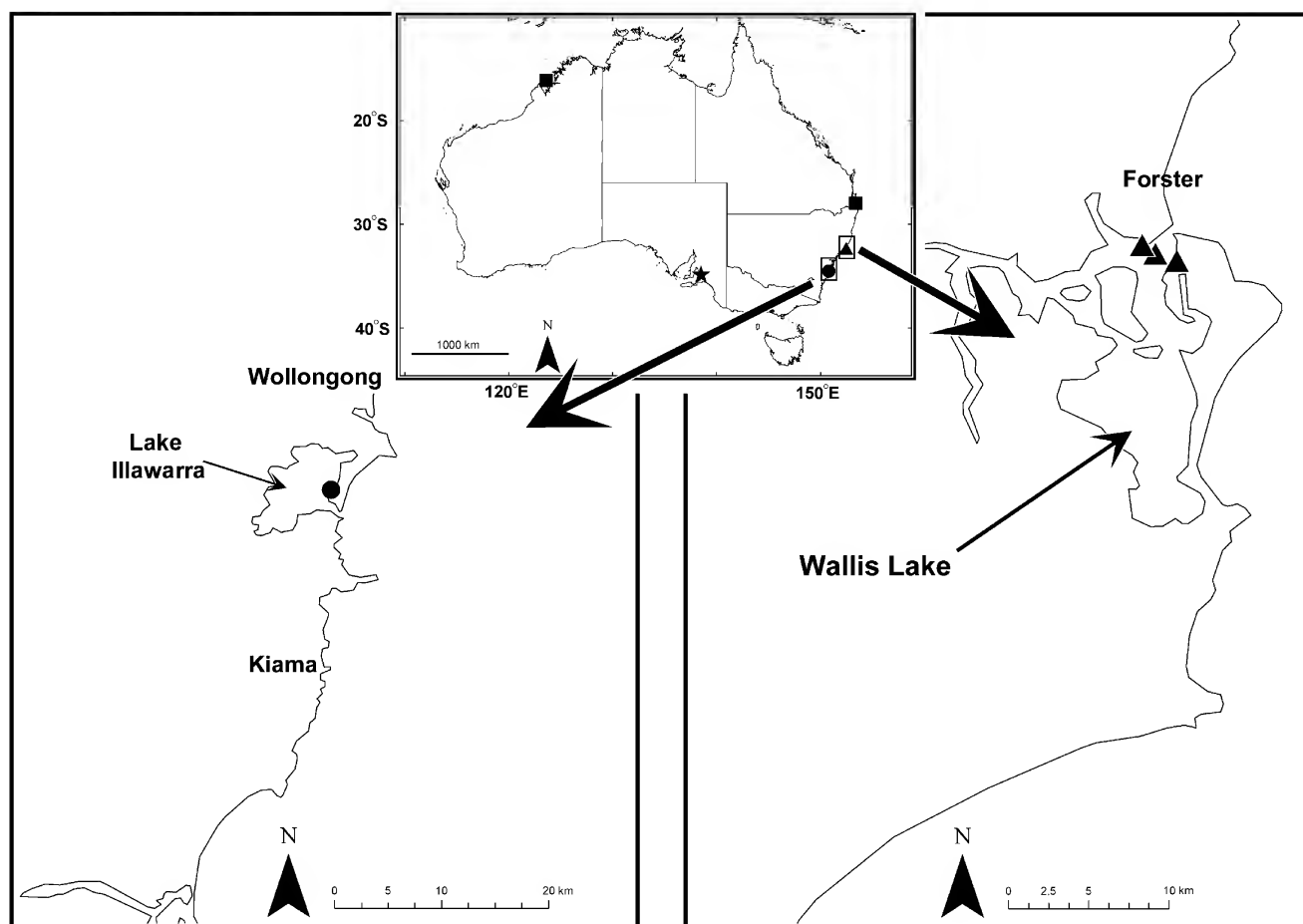


Figure 1. Location of previous southern records of *Cassiopea* from Australia (squares) and new localities reported here (circles and triangles), star represents anomalous record from Torrens Island Power Station.

Bigelow, 1892 (Gershwin *et al.*, 2010; WoRMS, 2014). Unfortunately, the correct name applicable to specimens from various locations is problematic (Holland *et al.*, 2004) and undescribed species are known (Gershwin *et al.*, 2010). Therefore, few species of *Cassiopea* can presently be accurately identified.

The genus is widely distributed in the tropics (Holland *et al.*, 2004) but also acknowledged as globally invasive (Graham & Bayha, 2007). As early as 1886, *C. andromeda* from the Red Sea was recorded in the Suez Canal, and soon after in the Mediterranean Sea off Cyprus; today it is known from the Aegean coast of Turkey (Gülşahin & Tarkan, 2012) and the central Mediterranean Sea off Malta (Schembri *et al.*, 2009). Other incursions are recorded from Hawaii (Holland *et al.*, 2004). In Australia, five named species or subspecies (*C. andromeda andromeda*, *C. andromeda baduensis*, *C. maremetensis*, *C. ndrosia*, *C. ornata*) and two undescribed species have been reported (Gershwin *et al.*, 2010). Péron & Lesueur (1810) described *Cassiopea dieuphila* from northwestern Australia but its taxonomic status is presently indeterminate. Previous southernmost Australian records of *Cassiopea* (Fig. 1) are from Queensland and Western Australia, north of approximately 27°58'S on the east coast and 16°08'S on the west coast (Atlas of Living Australia, 2014). An additional anomalous record of *C. ndrosia* from

Angas Inlet, near Adelaide, South Australia (approximately 34°48'S 138°32'E) is associated with the warm water outlet of the Torrens Island Power Station where temperatures are raised 5–8°C above ambient (Southcott, 1982).

Here, we report the sudden, recent appearance of medusae of *Cassiopea* from two shallow, widely separated, coastal lakes on the central east coast of Australia based on both sightings and preserved specimens. These are the first records of *Cassiopea* and Cassiopeidae from temperate eastern Australia.

Materials and methods

In 2013 and 2014, the authors were contacted through colleagues by concerned members of the public seeking to identify jellyfish that had appeared in large numbers in their local waterways (Lake Illawarra, 2013, and Wallis Lake, 2014; Fig. 1) and considered unusual. Subsequently, examples of these jellyfish were collected and deposited in the collections of the Australian Museum (AM). Whole specimens are fixed in 4–10% formalin but non-formalin fixed frozen tissue samples have also been retained for genetic studies currently in progress. Specimen measurements indicate bell diameter (bd). The synonymy of *C. ndrosia* is restricted to the original citation and Australian records.

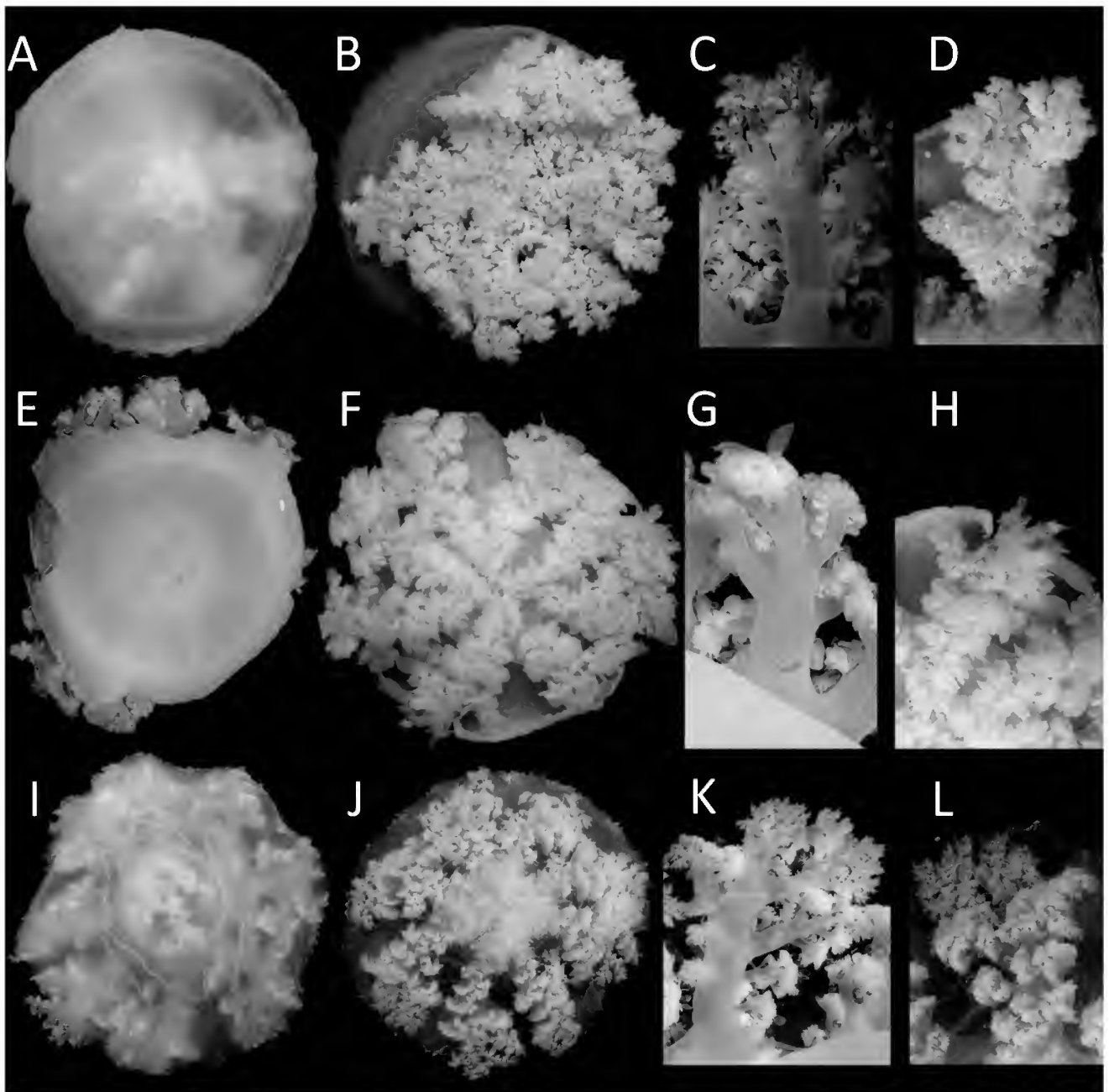


Figure 2. (A–D) *Cassiopea ndrosia*, bd 80 mm, Lake Illawarra, AM G.18075. (E–H) *Cassiopea* cf. *maremetens*, bd 80 mm, Wallis Lake, AM G.18155. (I–L) *Cassiopea maremetens*, bd 110 mm, Moreton Bay, paratype, QM G.6645. A, E, I, aboral surface; B, F, J, oral surface; C, G, K, aboral view of oral arm; D, H, L, oral view of oral arm.

Taxonomy

A taxonomic revision of *Cassiopea* is needed as there are a number of difficulties in recognizing species within the genus with currently used character suites (Holland, 2004; Gershwin *et al.*, 2010; Shapiro, 2014). On the basis, however, of characters highlighted by Mayer (1910) and Gershwin *et al.* (2010) in comparison with paratypes of *C. maremetens* in the Queensland Museum (QM G.6645, Fig. 2I–L) and other specimens in the collections of the Australian Museum (AM), it is apparent that two forms are present in the samples from New South Wales, identified here as *C. ndrosia* (Lake Illawarra) and *C. cf. maremetens* (Wallis Lake).

Cassiopeidae Tilesius, 1831

Cassiopea ndrosia Agassiz & Mayer, 1899

Figs 2A–D, 3A–B

Cassiopea ndrosia Agassiz & Mayer, 1899: 175, pl. 14, figs 45, 46; Stiasny, 1934: 913–921; Kramp, 1965: 265; Southcott, 1982: 159, pls. 15.3, 15.4; Gershwin *et al.*, 2010: 91.

Material examined. AM G.18074, 1 specimen, from bottom of canal through “Jetties By The Lake Lifestyle Village” at Windang Road, Lake Illawarra, New South Wales, Australia,

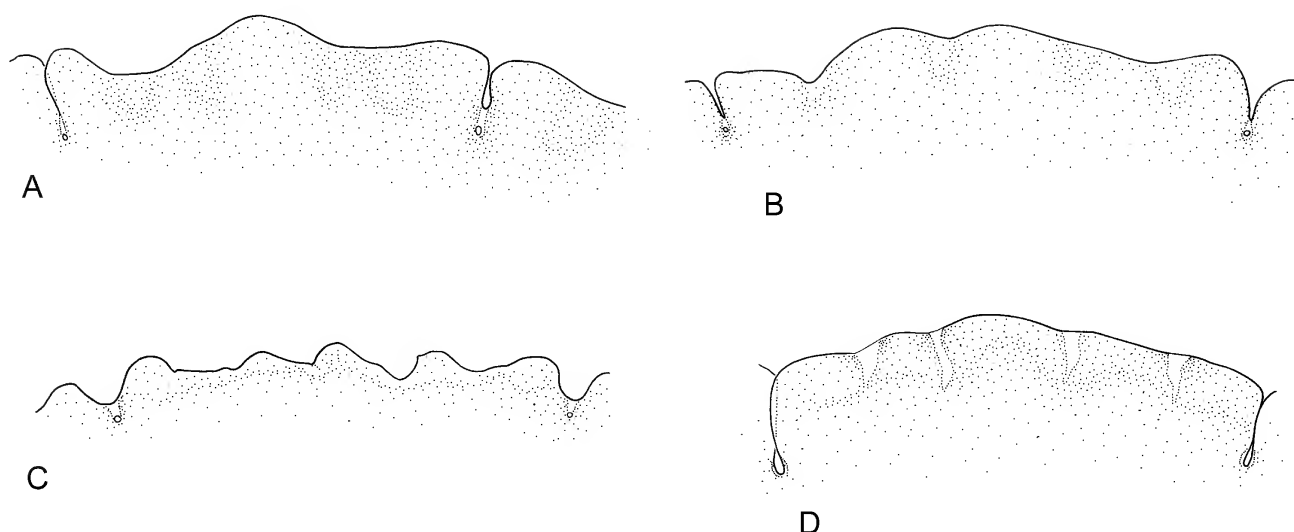


Figure 3. Lappets, oral view. (A) *Cassiopea ndrosia*, Lake Illawarra, bd 80 mm, AM G.18075. (B) *Cassiopea ndrosia*, bd 100 mm, Hayman Island, AM G. 13568. (C) *Cassiopea* cf. *maremetens*, bd 90 mm, Wallis Lake, AM G.18156. (D) *Cassiopea maremetens*, paratype, bd 110 mm, Moreton Bay, QM G6645. Scale = 5.0 mm.

34°31'36"S 150°51'53"E, 0–1 m, M. Cameron, 8 May 2013; AM G.18075, 1 specimen (80 mm), locality data as for G.18074; AM G.13568, 3 specimens (90–120 mm), Hayman Island, Whitsunday Passage, Queensland, 20°03'S 148°53'E, tidal flat, coll. F. A. McNeill, January 1933.

Remarks. The Lake Illawarra specimens, collected in 2013, conform well to *C. ndrosia* according to diagnostic characters indicated by Mayer (1910), Southcott (1982), Gershwin *et al.* (2010: tab. 9) and comparative specimens from Queensland (AM P.13568; originally reported by Stiasny, 1934). The “pinnate” branching of the oral arms (i.e., with lateral arms opposing each other on the primary arm) is the most significant distinction from *C. maremetens* in which the lateral arms “alternate” in position along the primary arm (see Fig. 2C for *C. ndrosia* from Lake Illawarra versus Fig. 2K for *C. maremetens*). Additionally, the oral arms are subequally branched just distal of the midpoint of the total arm length in the material from Lake Illawarra, a condition found in *C. maremetens* only on the distal extremity of the oral arms due to the arrangement of alternate branching of the proximal lateral arms. The vesicles are elongate and leaf-shaped, of varying size, and numerous, especially toward the centre. Numbers of these vesicles are relatively small and no longer than the width of the oral arms, however, initially giving the impression that relatively fewer vesicles are present until examined under magnification. The Lake Illawarra and Queensland (Hayman Island) specimens agree closely and correspond to the current concept of *C. ndrosia* (see Mayer, 1910; Gershwin *et al.*, 2010). *Cassiopea ndrosia*, first described from Fiji, is currently attributed a wide distribution in the central and western Pacific, from French Polynesia to Australia and Japan (Kramp, 1965); records, however, require confirmation (Holland *et al.*, 2004; Gershwin *et al.*, 2010). In Australia, *C. ndrosia* has been reported from Queensland (Torres Strait, the Gold Coast, Hayman Island; Stiasny, 1934; Kramp, 1965) and South Australia (Angas Inlet; Southcott, 1982).

Gershwin *et al.* (2010) noted the very close similarity between *C. ndrosia* and *C. maremetens*, with the chief differences recognized in the branching of the oral arms

(pinnate versus alternate), and shape and number of lappets per paramere (1–2 indistinctly lobed versus 4 square, deeply incised); we question the latter distinction below under the account of *C. cf. maremetens*.

The collector of the Lake Illawarra specimens noted this jellyfish started appearing and multiplying two weeks prior to the samples being obtained. Over 100 individuals were observed at this time at the same location—a small, shallow, artificial canal (8–10 m wide, approximately 100 m long, less than 1 m deep) within a residential village on the Lake Illawarra foreshore (Fig. 4A). Water temperatures measured daily within the canal for over a week while the jellyfish were present ranged from 17 to 22°C but within two months of collection, and the onset of cooler winter weather (water temperature not measured), the population disappeared (M. Cameron, pers. comm.). A check of the area in May 2014 and discussion with local residents living next to the canal indicates the jellyfish have not reappeared at this location. Other sites along the shoreline within Lake Illawarra were also inspected in May 2014 without encountering any *Cassiopea*.

Cassiopea cf. *maremetens* Gershwin, Zeidler & Davie, 2010

Figs 2E–H, 3C, 4E,F

Material examined. AM G.18137, 1 specimen, in channel splitting Godwin Island approximately one third distance from southern shore, Breckenridge Channel, Wallis Lake, New South Wales, Australia, 32°11'45"S 152°29'56"E, R. Pearce, 15 August 2014. AM G.18138, 1 specimen, collection data as for G.18137. AM G.18139, 11 specimens, collection data as for G.18137. AM G.18143–18155, single specimens; AM G.18156, 13 specimens, Pipers Creek, behind Smugglers Cove Caravan Park, Wallis Lake, New South Wales, Australia, 32°12'00"S 152°30'39"E, R. Pearce, 18 September 2014. AM G.18181–18183, 4 specimens, inlet on south east side of Mather Island, Wallis Lake, New South Wales, Australia, 32°11'26"S 152°29'36"E, S. J. Keable & A. D. Hegedus, 28 April 2015. AM G.18184, 1 specimen,

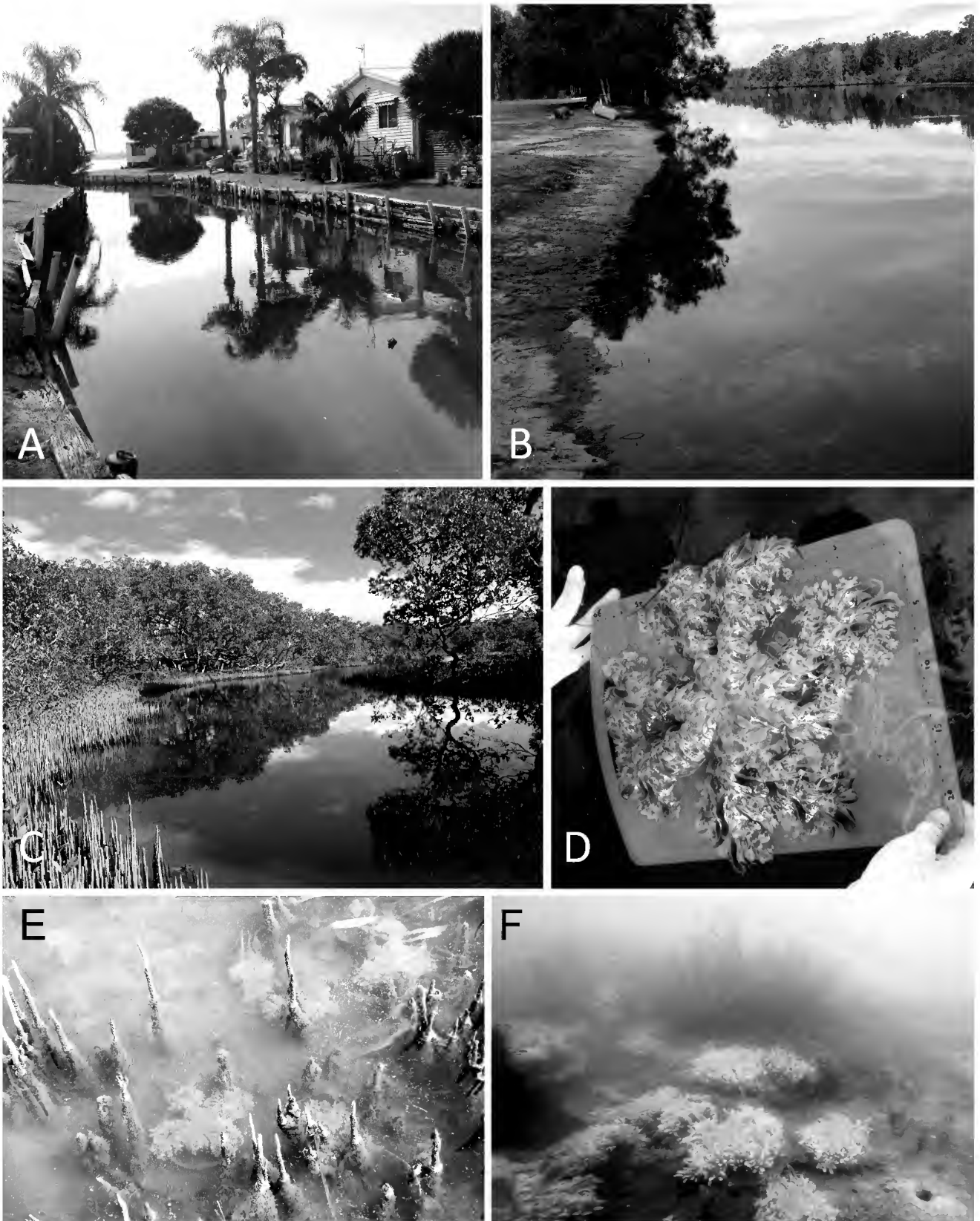


Figure 4. (A) Collection site for *Cassiopea ndrosia* from Lake Illawarra, canal through “Jetties By The Lake Lifestyle Village” looking toward lake. (B) Collection site for *Cassiopea* cf. *maremetens* from Pipers Creek, Wallis Lake, looking toward lake. (C) collection site for *Cassiopea* cf. *maremetens* from inlet on south east side of Mather Island, Wallis Lake, looking toward lake. (D) field measurement of bell diameter of c.210 mm for *Cassiopea* cf. *maremetens* from Pipers Creek, Wallis Lake. (E–F) Aggregation of *Cassiopea* cf. *maremetens* at inlet on southeast side of Mather Island, Wallis Lake from above and below water surface, respectively.

Pipers Creek within Smugglers Cove Caravan Park, Wallis Lake, New South Wales, Australia, 32°11'58"S 152°30'39"E, S. J. Keable & A. Murray, 30 April 2015. Bell diameter 35 mm (AM G.18182) to 210 mm (AM G.18139).

Comparative material of *C. maremetens*. QM G6645, 3 paratypes (110–130 mm), Mud Island, Moreton Bay, Queensland, C. Wallace, 8 April 1972.

Remarks. The Wallis Lake specimens appear to be closest to *C. maremetens* Gershwin, Zeidler & Davie, 2010, from Queensland (Figs 2I–L, 3D) (type locality, Lake Magellan, southwest of Caloundra, 26°49'42"S 153°06'48.6"E), with which they agree in most respects including exumbrella conformation, branching pattern of the oral tentacles and the numbers of rhopalia (19–21) (Gershwin *et al.*, 2010). The material from Wallis Lake (Fig. 2G) agrees with type material of *C. maremetens* (QM G6645; Fig. 2K), and most noticeably differs from the Lake Illawarra specimens (Fig. 2C), in having alternating (i.e., non-opposing) rather than pinnate lateral branches along the length of the oral arms and lacking a distinct subequal bifurcation just distal to the midpoint of the primary arm. They differ, however, from both *C. maremetens* sensu stricto and *C. ndrosia* in the presence of numerous, large, conspicuous vesicles along the length of these arms (compare Fig. 2H and Fig. 2D [*C. ndrosia*, Lake Illawarra] and Fig. 2L [*C. maremetens*]). The vesicles are variably leaf shaped (generally slightly broader in the distal half, maximum width approximately one-third length), and generally as wide as the lateral arm branches. The presence of the numerous large vesicles on the oral arms is the most significant distinction between the Wallis Lake specimens and *C. maremetens* sensu stricto, which has few or no vesicles. Gershwin *et al.* (2010), however, noted they could not adequately assess the significance of the presence or absence of vesicles in their material, whether a polymorphism or indicative of an additional unrecognized species. Just as Gershwin *et al.* (2010) observed no correlation between body size and presence of vesicles on the oral arms in *C. maremetens*, the vesicles in the Wallis Lake specimens are similarly numerous across the size range.

Significantly, our Wallis Lake specimens also differ from the description of *C. maremetens* in the lappet shape and arrangement (Fig. 3C–D). Ocelli are present in the Wallis Lake specimens, absent in *C. maremetens*. The margin of the parameres in the Wallis Lake specimens are sinuous, resulting in 4–5 low, rounded lobes (Fig. 3C). In contrast, the lappets of *C. maremetens* are reported as square and deeply incised, with four per paramere (Gershwin *et al.*, 2010). Close examination of paratypes of *C. maremetens*, however, revealed the squared, apparently deep incisions are bridged by transparent exumbrella membrane (Fig. 3D). Thus, instead of being deeply incised, the outline of the lappets of *C. maremetens* (at least in the paratypes examined) is actually essentially sinuous and indistinctly lobate, much like that of *C. ndrosia*. The lappets in the Wallis Lake material differ from *C. maremetens* in having a more strongly sinuous margin with more numerous lobes per paramere. The differences in lappet shape and vesicle complement in comparison to *C. maremetens* suggest that the Wallis Lake specimens may represent a separate, possibly undescribed species. Pending further study, however, we tentatively identify our material as *C. cf. maremetens* to highlight its similarity to *C. maremetens*. *Cassiopea maremetens* sensu

stricto is presently known from Bentinck Island, Gulf of Carpentaria, Queensland (c. 17°03'34"S 139°29'09"E) to Moreton Bay on the Queensland east coast (27°48'S 153°24'E). Reports of *C. andromeda* from Southport, Queensland (27°58'S 153°25'E), just south of Moreton Bay, may also represent *C. maremetens* (Gershwin *et al.*, 2010).

The original collector of *Cassiopea* cf. *maremetens* from Wallis Lake first observed these jellyfish “in their hundreds” in Pipers Creek in 2009. The 2014 outbreak in the vicinity of Godwin Island (reported as “in large numbers within a small area”), documented here with specimens, was noticed on or near 2 August 2014 although specimens were not collected until 15 August 2014. Specimens of *C. cf. maremetens* were obtained again from the same location in Pipers Creek in September 2014.

Subsequent fieldwork in Wallis Lake in April 2015 confirmed the continued presence of *C. cf. maremetens* in Pipers Creek (Fig. 4B) and at a third locality within the lake adjacent to the shore at Mather Island (Fig. 4C). A 75 m transect line was placed randomly along the shoreline in both these locations and *Cassiopea* within 1 m of the shore along this distance were counted. Five randomly selected individuals from each transect were also measured for bell diameter. At Pipers Creek, 30 individuals were present along the transect, the bell diameter of the individuals measured ranged from 120 to 210 mm (Fig. 4D) with a mean of 170 mm. At Mather Island 24 individuals were present along the transect, those measured ranged in size from 40–70 mm with a mean of 53 mm. Distribution of *Cassiopea* appeared patchy. Outside the transects, dense aggregations were observed (Fig. 4E,F) with up to 35 per square metre at Mather Island. A water temperature of 21.5°C and a salinity of 28.7 parts per thousand was recorded during the Mather Island transect and a salinity of 12.1 parts per thousand at Pipers Creek. *Cassiopea* were observed lying with the aboral surface resting on very soft sediment in depths of 10–100 cm.

Discussion

The impacts (both ecological and economic) and mechanisms behind invasions and population explosions of jellyfish have received considerable recent interest (Graham & Bayha, 2007; Gershwin, 2013; Pitt & Lucas, 2014), influencing, for example, commercial fisheries, tourism and trophic structures. Species of *Cassiopea* feature in these reports as a globally invasive genus (see references cited above).

Cassiopea has not previously been recorded from New South Wales. Pitt *et al.* (2006) note jellyfish as the most conspicuous animals in Lake Illawarra and indicate the three species most commonly seen as *Catostylus mosaicus*, *Phyllorhiza punctata* and *Aurelia aurita* but not *Cassiopea*. Similarly, other scyphozoans such as *Catostylus mosaicus* have been documented from Wallis Lake (Pitt & Kingsford, 2000) but not *Cassiopea*.

The samples reported here, therefore, represent a range extension for *Cassiopea* of approximately 600 km (Wallis Lake) to 900 km (Lake Illawarra) southward of the previous southern instance on the east Australian coast, Southport, Queensland. Given the lack of previous records, the apparently sudden appearance in large numbers is significant.

We do not discount the role of normal environmental change in driving changes in species' ranges. However, *Cassiopea* are not considered to have strong natural dispersal

capabilities (Holland *et al.*, 2004) so it is highly plausible that anthropogenic influences are involved. Given the isolated and significantly disjunct occurrences of the two forms recorded here, that at least one of the present forms does not appear referable to known Australian species, and the genus is conspicuous where it occurs, the new records from New South Wales do appear to represent new introductions. Even if the Wallis Lake form is referable to true *C. maremetens*, the absence of records from intermediate localities in New South Wales is consistent with human mediated translocation. Different factors may also be implicated in the different situations of Wallis Lake compared to Lake Illawarra. Vectors suggested for anthropogenic transport of *Cassiopea* include shipping (through biofouling or ballast water release), intentional or unintentional direct release and via “live rock” from aquaria (Holland *et al.*, 2004; Graham & Bayha, 2007; Schembri *et al.*, 2009). Both lakes have considerable recreational and other domestic vessel traffic, and Lake Illawarra is close to a major population centre, Wollongong and commercial port, Port Kembla. Increased water temperatures associated with global warming or a perturbation of the East Australian Current could also be involved, although one would predict the occurrence of *Cassiopea* from intermediate localities between southern Queensland and Wallis Lake–Lake Illawarra.

The presence of *Cassiopea* medusae in Lake Illawarra currently appears to be ephemeral, but the dormant reproductive potential of the polyp stage of jellyfish (Gershwin, 2013) means another outbreak could occur again in the future. Conversely, *Cassiopea* appears to be established in Wallis Lake where it is continuously present over consecutive seasons. Given the amenity, economic asset and ecological benefits these waterways provide and the possible negative impacts invasive jellyfish are known to have, it is imperative that these outbreaks are studied further, and the vectors for translocation identified. Moreover, taxonomic revision of the genus is urgently required in order that incursions can be accurately recognized and tracked. We hope publication of these initial records will stimulate further investigations.

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On Some Types of Birds (Aves) from the Solomon Islands Named by Edward Pierson Ramsay

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ABSTRACT. In the years 1879–1882 the Curator of the Australian Museum, Edward P. Ramsay, named 15 bird taxa largely based upon specimens collected in the Solomon Islands by James F. Cockerell in 1878. Investigations based upon the original correspondence and examination of the specimens determined that the specimens used by Ramsay to describe these taxa were dispersed to at least six museums. The number of types collected by Cockerell is larger than previously thought, with only 40 of the 93 known extant type specimens being held by the Australian Museum. The dates of publication of these taxa, the journals of original publication and related nomenclatorial issues are discussed.

KEYWORDS. Aves, Solomon Islands, zoological nomenclature, Edward Ramsay, James Cockerell.

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In 1995, while looking for type specimens in the bird collections of Museum Victoria, I came across several specimens that are arguably types of taxa from the Solomon Islands. These taxa were described by Edward Pierson Ramsay, Curator of the Australian Museum from 1874 to 1894, and are represented amongst the type specimens held in the Australian Museum (Etheridge, 1917; Longmore, 1991). Further research has revealed that type specimens from these collections from the Solomon Islands were dispersed to at least six museums.

The specimens in Museum Victoria were purchased from James F. Cockerell in 1879. James F. Cockerell was, like his father John T. Cockerell, a natural history collector (Whittell, 1954). He collected specimens on Cape York Peninsula in 1867–1868, in Samoa and the Bismarck Islands in 1875–1876, the Solomon Islands in 1878, Western Australia in 1879, and Cape York and the Aru Islands in 1880. He finally settled near Mildura in Victoria where he collected for the South Australian Museum, both in the local area and in South Australia itself.

The specimens referred to in this paper are from Cockerell's collections made when aboard the schooner *Ariel* under the command of Captain Neil Brodie in late 1878. Cockerell is known to have collected at three localities, Cape Pitt, the south-eastern point of Nggatokae in the New Georgia group; Lango [now = Lungga] on Guadalcanal; and the island of Savo (Whittell, 1954; Ramsay, 1879b). It is not known exactly when the specimens were collected, though many have details on tags that give general collection dates of October or November 1878. The *Ariel* was still present in Sydney in late May 1878 when it was reported to be tied up to Grafton Wharf (Anon., 1878). According to a newspaper account, the *Ariel* left the Solomon Islands on 21 December 1878 and arrived in Sydney on 6 January 1879 (Anon., 1879). Nothing is really known of what business was actually being conducted by the *Ariel*. The *Ariel* left Sydney again on 26 March 1880 on her last voyage and was sunk in deep water after hitting a coral reef—apparently off the coast of Guadalcanal (Anon., 1880). Brodie and the crew “together with a large number of natives” were able to make shore. Two

of the crew were said to have been poisoned by “natives” and yet according to the newspaper account, Brodie was apparently on good terms with them.

Methods

Relevant specimens of the taxa described by Ramsay were examined in the following Australian museums over several years: Australian Museum, Sydney (AM); Macleay Museum (University of Sydney), Sydney (MM); and Museum Victoria, Melbourne (NMV). The following museums in Italy were visited during August–September 1994: Museo Civico di Storia Naturale, Milano (MSNM); Museo Civico di Storia natural “G. Doria”, Genova (MSNG) and the Museo di Zoologia dell’Università di Torino (MZUT), specimens now housed in the Museo Regionale di Scienze Naturale, MRSN).

Details of specimens in the Queensland Museum, Brisbane (QM) and the Bird Section of The Natural History Museum Tring, United Kingdom (BMNH) were inferred from Ingram (1987), Longmore (1991) and Warren & Harrison (1971), and through correspondence with staff at these museums.

Where possible, the specimens were examined to see if the plumages and morphology conformed to the descriptions given by Ramsay. Specimen labels registers and relevant correspondence held at these institutions were examined. The extensive files of Ramsay’s correspondence and diaries held in the Mitchell Library, State Library of NSW, Sydney, were also consulted.

Taxonomic nomenclature. The nomenclature generally follows Dickinson & Remsen (2013) and Dickinson & Christidis (2014). Issues of nomenclature arising from these specimens and Ramsay’s descriptions and publications are discussed below.

Results

Ramsay’s acquisition of the specimens

Cockerell evidently met Ramsay soon after the arrival of the *Ariel* in Sydney in early 1879, though the specimens were not acquired by Ramsay on their first meeting. On 8 January Cockerell wrote to Ramsay,

“I would wish if it were convenient to you for you to go on board the *Ariel* tomorrow morning and inspect the plants. With regard to the birds etc, I give you full power to act for me but I wish to hold my own portion of these in preference to the coin as I have already told you” (letter in Ramsay papers, Mitchell Library, State Library of NSW, ML.MSS.1589/3).

Thus the entire collection was examined by Ramsay within a few days of Cockerell’s arrival. As with most biologists of the latter half of the nineteenth century, Ramsay rarely designated type specimens in his descriptions. Consequently all the specimens in Cockerell’s collection that were taxa named by Ramsay in his initial paper on the collection are available as types.

Ramsay may have helped Cockerell with the sale of the collection. Cockerell’s collection went to Museum Victoria after having first passed through Ramsay’s hands, as confirmed by letters in the archives of the Museum Victoria ornithology department (examined in 1995). On 14 January 1879, Ramsay sent a telegraph to Professor Frederick McCoy, the first curator of Museum Victoria:

“Cockerell offers splendid collection at five shilling each from Solomon Islands [:] Shall I send you a set pair of each species cheap [?]”

Two days later, on 16 January, Ramsay again wrote to McCoy:

“I have told Cockerell that I would select a set of his birds &c for you but he says he is going down to Melbourne himself and will show you all his collections [:] he has some good things among them.

“I do not find as many new things among Cockerell’s birds as I expected—but still there are some, these I have described and named and send you a list of them in case we should both be naming the same species—which would be very undesirable and only burden science with useless synonyms.

“The following are the birds which I have described as New—in our Linn. Soc. Proceed.

<i>Myzomela personata</i>	sp. nov.
<i>Monarcha castanea</i>	„ „
<i>Rhipidura cockerelli</i>	„ „
„ <i>erebi</i>	„ „
<i>Monarcha nigrogularis</i>	„ „
<i>Ptilopus alexandræ</i>	„ „
<i>Centropus alboviolacea</i>	„ „
<i>Graucalus assimilis</i>	„ „
<i>Myiagra albicans</i>	„ „ ...

Publication and nomenclatural issues

Ramsay described several species at a meeting of the Linnean Society of New South Wales on 29 January 1879 (Ramsay, 1879b). Although Ramsay’s letter of 16 January 1879 suggests that he had already decided the names, those published in the *Proceedings of the Linnean Society of New South Wales* (hereafter *Proceedings*) were almost entirely different (Ramsay, 1879b). The only name described at the meeting that is directly analogous is *Sauloprocta cockerelli*, for *Rhipidura cockerelli*.

A further problem arises with Ramsay’s description of Cockerell’s collections in the earlier publication of a summary paper in *Nature* (Ramsay, 1879a). The paper in the *Proceedings* was published on 16 June 1879 (see Fletcher, 1896 for publication dates of the *Proceedings*) while the paper in *Nature* dates from 5 June 1879. Again there were differences between the two sets of names. Longmore (1991) outlined these differences and once again, apart from the description of *Sauloprocta cockerellii* (vs. *Rhipidura cockerelli*), none of the names is similar to those used in Ramsay’s letter to McCoy (Table 1).

Warren & Harrison (1971) suggested that the names in *Nature* were *nomina nuda*, i.e. not valid descriptions. However, the descriptions, although rudimentary, are valid, and were recognized as such by, amongst others, Mathews (1930), Salomonsen (1967), Schodde (1977), Watson *et al.* (1986) and Longmore (1991). Furthermore, several of the names found only in the *Nature* paper are used in standard works; for example *Monarcha barbatus* and *Myzomela melanocephala* were both used in Mayr (1945a), Sibley & Monroe (1990), Dickinson (2003), Dutson (2011) and Dickinson & Christidis (2014), the latter two publications listing *M. barbatus* as *Symphysiarhus barbatus*.

Table 1. Names used by Ramsay in *Nature* in 1879 (Ramsay, 1879a) versus those he used in the *Proceedings* (Ramsay, 1879b)

Name used in <i>Nature</i> (published 5 June 1879)	Name in <i>Proceedings</i> (16 June 1879)
<i>Myiagra ferocyanea</i>	<i>Myiagra ferro-cyanea</i>
<i>Monarcha barbata</i>	<i>Monarcha brodiei</i>
<i>Sauloprocta cockerellii</i>	<i>Sauloprocta cockerelli</i>
<i>Rhissidura rufofronta</i>	<i>Rhipidura rubrofrontata</i>
<i>Cinnyris melanocephalus</i>	<i>Cinnyris (?) dubia</i>

Four of the names listed in Ramsay's letter to McCoy, *Ptilopus alexandrae*, *Centropus albioviolacea*, *Rhipidura erebi* and *Graucalus assimilis*, have no corresponding new name in Ramsay's paper in *Nature* and are *nomina nuda*. However, *Graucalus assimilis* may refer to *Graucalus pusillus* described in Ramsay's first 1879 paper in the *Proceedings*, and *Ptilopus alexandrae* may refer to *Ptilopus lewisii*, which Ramsay published later using material from Cockerell's collection (Ramsay, 1882a,c).

Ramsay (1881b) corrected the spelling of *Rhissidura rufofronta* to *Rhipidura rubrofrontata*, specifically referring to the *Nature* article. This was probably prompted by criticism of Ramsay's spelling errors in a paper in *The Ibis* by Salvadori (1880) and not anticipated by Ramsay as suggested by Longmore (1991). In 1882, in a summary paper on the birds of the Solomons, Ramsay used the spelling *Myiagra ferocyanea* and *Piezorhynchus* [instead of *Monarcha*] *brodiei* as used in the *Proceedings*, but then used *Sauloprocta cockerellii* and *Cinnyris melanocephalus* as used in *Nature* (Ramsay, 1882f). Evidently Ramsay's application of these names was not set in stone.

Ramsay wrote several other papers on birds from the Solomon Islands at least partly based on Cockerell's collections of 1878. In 1882, Ramsay noted that eight taxa were described in the first 1879 *Proceedings* paper (Ramsay, 1882f). He then listed another six taxa represented in Cockerell's collection that were described in the intervening years: "*Graucalus elegans*, *Baza gurneyi*, *Astur pulchellus*, *Ptilopus lewisii*, *Macropygia rufrocastanea*" and "*Halcyon tristrami*".

Several of Cockerell's specimens of these taxa are types, though Ramsay's use of *Halcyon tristrami* was an error. *Halcyon* [now = *Todiramphus*] *chloris tristrami* is now considered to be restricted to New Britain. It was described by Edgar Layard from a single specimen with the incorrect locality of San Cristobal [now = Makira] (Layard, 1880; Rothschild & Hartert, 1905; Peters, 1945). Ramsay's separate error is explained through a specimen in the Australian Museum (O.18644) collected at Cape Pitt and labelled on the reverse, "var. of *H. chloris*?". This specimen is evidently the one collected by Cockerell in 1878. According to Ramsay (1879b), Cockerell collected only one specimen of "*Halcyon chloris* var.", and this came from Cape Pitt. The subspecies of *T. chloris* from the Solomons south to Guadalcanal is now usually given as *T. c. alberti* (Rothschild & Hartert, 1905), and is slightly smaller in size and darker above than *T. c. tristrami* from New Britain, whereas *T. c. solomonis* from San Cristobal has paler underparts than *T. c. alberti* and has a broad rufous superciliary stripe (Rothschild & Hartert, 1905; Mayr, 1936; Peters, 1945; Fry *et al.*, 1992; Dutson, 2011). Thus the Cape Pitt specimen is now *T. c. alberti* and is closer in appearance to *T. c. tristrami* than *T. c. solomonis*.

Two of the additional taxa mentioned by Ramsay in 1882 as being represented in Cockerell's collection were again described in *Nature* rather than the *Proceedings*. A further paper of Ramsay's in *Nature* was also published in 1881 (Ramsay, 1881a). Even though these three later papers in *Nature* were largely based on other collections, it is worthwhile listing these taxa and their variant spellings (Table 2).

Table 2. Ramsay's names used in papers in *Nature* and the *Proceedings* in 1881 and 1882.

Ramsay (1881a,b)	Name used in <i>Nature</i> (21 July 1881)	Name used in <i>Proceedings</i> (12 September 1881)
	<i>Graucalus elegans</i>	<i>Graucalus elegans</i>
	<i>Piezorhynchus Richardsii</i>	<i>Piezorhynchus Richardsii</i>
	<i>Myzomela Tristrami</i>	<i>Myzomela Tristrami</i>
	<i>Myzomela pulcherrima</i>	<i>Myzomela pulcherrima</i>
	<i>Zosterops (Tephros?) olivaceus</i>	<i>Tephros olivaceus</i>
	<i>Nasiterna finschii</i>	<i>Nasiterna Finschii</i>
Ramsay (1882a,d)	Name used in <i>Nature</i> (19 January 1882)	Name used in <i>Proceedings</i> (20 March 1882)
	<i>Astur versicolor</i>	<i>Astur versicolor</i>
	<i>Ianthenas philippinae</i>	<i>Ianthenas philippinae</i>
	<i>Ptilopus richardsii</i>	<i>Ptilopus Richardsi</i>
	<i>Ptilopus lewisii</i>	<i>Ptilopus Lewisi</i>
	<i>Chalcophaps mortoni</i>	<i>Chalcophaps Mortoni</i>
	<i>Sternoides minor</i>	<i>Sturnoides minor</i>
	<i>Plectorhyncha fulviventrtris</i>	<i>Plectorhyncha (?) fulviventrtris</i>
Ramsay (1882c,e)	Name used in <i>Nature</i> (9 February 1882)	Name used in <i>Proceedings</i> (20 March 1882)
	<i>Halcyon salmonis</i>	<i>Halcyon solomonis</i>
	<i>Rhipidura tenebrosa</i>	<i>Rhipidura tenebrosa</i>

Citation of the first 1882 *Nature* paper with Ramsay as the author often occurs. The variants of spelling of *Ptilinopus richardsii* and *Ptilinopus viridis lewisii* are in the standard literature, largely through their use in Peters (1937). However, the earlier publication of the 1881 paper appears to have gone almost unnoticed, indeed it was overlooked in the same volume of Peters for *Micropsitta finschii*.

The only significant change in the spelling of any name in the 1881 paper was that of *Tephras olivaceus* where it is given as *Zosterops olivaceus* in the *Nature* article, presumably a typographical error. This change will be examined separately in a future paper.

The name "*Halcyon salmonis*" in the second 1882 paper in *Nature* has not been used since for the taxon now known as *Halcyon* (or *Todiramphus*) *chloris solomonis*. As such it is an unused senior synonym and should not be used. The type locality for this taxon was merely noted as the "Solomon Islands" in both *Nature* and the *Proceedings*. However, in a later paper Ramsay indicated that specimens were received from Alex Morton and John Stephens from Ugi and San Cristobal (Ramsay, 1882f).

Ramsay intentionally sent his papers to *Nature*. In one of his diaries in the Mitchell Library is the note "Nov 30th 1881. Read paper on two new species of Bds from Ugi. *Halcyon salamonis*, *Rhipidura tenebrosa*. Sent memo of the meeting to 'Nature' on 2nd Dec" (ML.MSS 2278 Add on 544). In the issue of *Nature* in question, 9 February 1882, there are references to all the papers given at the relevant meeting of the Linnean Society of NSW. In a sense this was a forerunner to the later published *Abstracts of the Proceedings of the Linnean Society of New South Wales* (hereafter *Abstracts*). Partial sets of the *Abstracts* are found in both the Australian Museum Library and the Mitchell Library. The earliest numbers in these sets date from the meeting of 27 September 1882, the meeting following the fire that destroyed the Garden Palace in Sydney's Domain on 22 September 1882. The Australian Museum lost its ethnological and technical collections in the fire (Strahan, 1979) and may have lost earlier issues of the *Abstracts*. The Linnean Society of NSW also lost its Library, equipment and specimens in the fire (Strahan, 1979). Many later issues of the *Abstracts*, apart from surviving in original form in the Australian Museum and Mitchell Libraries, were reprinted in the German journal *Zoologischer Anzeiger* and the Melbourne-based journal *Southern Science Record*. There are additional earlier accounts in *Nature* for the meetings from June and July 1882, though there are no new names involved. It would be interesting to know if any published *Abstracts* exist for meetings of the Linnean Society of NSW from before 27 September 1882, but it is likely that Ramsay ceased sending papers to *Nature* following the commencement of the publication of the *Abstracts* which provided a more rapid publication of his names.

Dispersal of the specimens

Cockerell apparently delivered his specimens to Museum Victoria during January 1879. Most of these specimens have tags dated "Jan.23/79". The specimens were all wrapped separately in wide strips of paper fastened as tubes with a pin. These strips were annotated by Cockerell and most of the Melbourne specimens were still unregistered and wrapped in the paper strips when examined in 1995. Nearly all the strips with Cockerell's handwriting were removed from the

specimens in the Australian Museum. However, at least one remains attached to the tag of a specimen of *Dicaeum aeneum* (AM O.18696). Cockerell's specimens from the Solomon Islands are fairly distinctive. They are cylindrical in shape and sometimes have a "waist" when the paper tube did not cover the entire bird. This cylindrical shape is common to Cockerell's specimens in the Australian Museum, Museum Victoria and those in another major repository of Cockerell's specimens at the Macleay Museum.

The bird collection in the Macleay Museum of the University of Sydney consists of around 9500 specimens and largely dates from 1874 to 1888, the period in which William John Macleay was actively collecting and acquiring bird specimens (Stanbury & Holland, 1988; S. Norrington, pers. comm.). Despite many type specimens being transferred on permanent loan to the Australian Museum in 1969 (Longmore, 1991), large numbers of type specimens and specimens of rare taxa still remain in the Macleay Museum (Fisher & Longmore, 1995; Fulton, 2001; McAllan, 2006). Unfortunately most of the specimens in this collection lack original labels, largely through the curation of the collection by George Masters from 1874 to 1912.

Nevertheless, all the specimens labelled "Solomon Islands" in this collection have the same cylindrical shape as the specimens in the Australian Museum and Museum Victoria. In 1929, J. J. Fletcher published a paper giving information on the sources of material found in the Macleay Museum where there is only one reference to birds coming from the Solomon Islands (Fletcher, 1929; Whittell, 1954). On page 267 it refers to donations to the Museum in 1879 and notes "Mr Cockerell—part of his collection (mammals, birds, over 100 species, reptiles, fish and insects) from the Solomon Islands". Stanbury (1969) suspected that some of these specimens were types, but gave no details of why he thought this was so and many were not included in the later transfer of types to the Australian Museum. Given that Ramsay was closely associated with Macleay (Strahan, 1979), it is not surprising that part of Cockerell's collection ended up in Macleay's Museum.

In his letter to McCoy of 16 January 1879, Ramsay wrote that he had seen the entire collection made by Cockerell before describing the new taxa. Consequently many of the types from the first paper on Cockerell's collection are in both Museum Victoria and the Macleay Museum. However, only some of the types from Ramsay's later publications that used specimens from Cockerell's collection can be said to be in these other museums. Even so, it is evident from occasional references in his papers, that Ramsay regularly visited the Macleay Museum (e.g., see the *Chalcophaps mortoni* account in Ramsay, 1882f). Furthermore, Ramsay visited Melbourne in 1880 (Strahan, 1979), and again in January 1881, when he helped McCoy identify some New Guinea bird specimens (letter from McCoy to Ramsay, Mitchell Library ZML.MSS 2169; also Ramsay diaries, Mitchell Library ML.MSS 2278 Add on 544).

Ramsay organized an exchange of several specimens with the Queensland Museum that finally took place in June 1883 when Ramsay was absent in Europe. Whether done intentionally or unintentionally, this exchange included a type specimen (Ingram, 1987). Although Cockerell disposed of most of his specimens within Australia, he also sold two type specimens to The Natural History Museum in London. These were registered into the collection in January 1884 (Warren & Harrison, 1971).

It also appears that Ramsay exchanged some types with Otto Finsch when he visited the Australian Museum in August 1881. A memo from Finsch to Ramsay written in Sydney notes, "I shall come in the course of this afternoon in order that we may begin to make some choices in regard to duplicates" (letter in Ramsay papers, Mitchell Library ML.MSS.1589/3). Some of the specimens concerned, including one evidently collected by Cockerell, were shortly afterwards acquired from Finsch by Count Turati and are now in the Museo Civico di Storia Naturale, Milano (McAllan *et al.*, 2005).

Ramsay also exchanged some specimens with Giacomo Doria in Genoa in early 1883. The species were identified for Doria by Tommaso Salvadori of Turin. Salvadori was given some of these specimens himself. Although some of Cockerell's specimens were included, no types of the taxa discussed here were involved.

Several of Cockerell's type specimens now in the Australian Museum were not registered into the collection until 1912 as they were previously part of the Ramsay family's collection, known as the "Dobroyde" collection (Hindwood, 1970; Longmore, 1991). Although separate registers exist for specimens in this collection dating from before 1869, there are no registers for later parts of the collection. On this basis some types could have been exchanged with other collectors or institutions before the Australian Museum's acquisition of the Dobroyde collection around 1896. This evidently includes a type specimen exchanged by Ramsay to The Natural History Museum in 1895, as the exchange does not appear in the Australian Museum registers (Warren & Harrison, 1971).

Type specimens collected by Cockerell in the Solomon Islands

The known type specimens from Cockerell's collections in the Solomon Islands are discussed below. All the specimens used in the description of the taxon concerned are listed, including those not actually collected by Cockerell. After each specimen number, the information found on attached specimen tags and in the register of the relative museum is quoted.

Specimens from the Dobroyde collection in the Australian Museum have no additional information in the Museum's registers beyond what is written on the tags and so only the details on the tags are given. It is unclear when the labels on these specimens were written. Although many of these tags are in Ramsay's handwriting, some appear to have been written by A. J. North. North initially was the personal curator of Ramsay's Dobroyde Collection in late 1886 before being employed by the Australian Museum (Cahill, 1998).

Most of the non-Australian collections in Museum Victoria were unregistered at the time of my initial examination in 1995. Exceptions to this were specimens of species whose distribution includes Australia and those that had been made into mounts. Consequently most of the registration numbers from Museum Victoria listed below that begin with a "B" were registered in September 1995.

In the late 1970s there was no existing register of the Macleay Museum bird collection, though Stanbury (1969) noted registration numbers for the specimens. All the specimens were re-registered by Graeme Phipps in the early

1980s (G. Phipps, pers. comm.). Consequently the Macleay Museum specimen numbers are totally different to those given by Stanbury (1969). The earliest remaining specimen labels attached to the Solomons collections in the Macleay Museum appear to have been written by George Masters. From the names used on the labels this may have occurred some time in late 1881 or early 1882 (i.e. after Ramsay's description of *Ptilopus lewisii* at the meeting of the Linnean Society of NSW on 31 August 1881, but before Masters was aware of Ramsay's description of *Baza gurneyi* which was published in the *Journal of the Linnean Society* [of London] in late January 1882).

Macropygia rufocastanea Ramsay, 1879, *Proceedings* 4: 314 (issued 1 December 1879)

[= *Macropygia mackinlayi arossi* Tristram, 1879 (issued October 1879)]

Australian Museum. Holotype: O.18711.

This specimen is from the Dobroyde collection and was registered in 1912. It is labelled in Ramsay's hand "Macropygia rufo-castanea, ad male?, Solomon Islands (J.C.) Type of the sp. EPR". Although specimen B.28151 in Museum Victoria and specimen B.2222a in the Macleay Museum were clearly both collected by Cockerell, they cannot be types, as only one specimen was referred to in Ramsay's description. Stanbury (1969) erroneously considered the Macleay Museum specimen a possible type. Salvadori (1880) noted that Ramsay had written him a letter indicating that Ramsay intended to name this taxon *Macropygia castanea*. If early *Abstracts* of the *Proceedings* can be found, it is possible they could antedate Tristram's *M. arossi*, as Ramsay named *M. rufocastanea* at the meeting of 25 June 1879. This may well be the case as in 1882 Ramsay used the name *rufocastanea* and placed *arossi* in synonymy (Ramsay, 1882f). However, *rufocastanea* would be an unused senior synonym and not available.

Ptilopus lewisii Ramsay, 1882, *Nature* 25: 282.

[= *Ptilinopus viridis lewisii* (Ramsay, 1882)]

Australian Museum. Two syntypes: A.3924, A.11558.

A.3924, does not have an original label. The register lists "Ptilopus viridis var. probably new species, Guadalcanar, Solomon Islds, Captain Brodie and Cockerell".

A.11558, the oldest label notes that it is "Ptilopus lewisi, Hab. Ugi Isld, sex female" and the register notes that it was collected by Alex Morton on Ugi and is a type. The locality of Ugi is incorrect for this species, and obviously is in error, even though this specimen was registered with other specimens of *Ptilinopus eugeniae* from Ugi.

Part of the confusion may result from Ramsay referring to specimens of "*Ptilopus eugeniae*" being collected at Ugi in his description of *P. lewisi* in the *Proceedings* (1882d), however this was only in the context of pointing out that *P. eugeniae* was not the same as *P. lewisi*. Ramsay (1882f) noted that *P. lewisi* was represented in Cockerell's collections. Furthermore, when Ramsay described the taxon, he specifically noted that it was included amongst Cockerell's specimens referred to in the first 1879 *Proceedings* paper

(Ramsay, 1879b, 1882c). Ramsay (1882d) later restricted the type locality of the taxon as “Florida and Malayta”, two islands that Cockerell did not visit. Ramsay’s diaries list the specimens brought back from the Solomon Islands in mid-1881 by the Australian Museum collector, Alex Morton (Mitchell Library ML.MSS 2278 Add on 544). Included in this listing are specimens of “*Ptilopus* sp nov (viridis) Florida & Malatta”. These specimens were evidently some of those used to describe *Ptilopus lewisii*, and the source of the locality given in Ramsay’s paper. As there were at least two specimens collected by Morton there is evidently a type specimen missing.

Macleay Museum. One syntype: B.2094.

Labelled as “*Ptilinopus lewisi*, Rams. Male. Solomon Is.” by Masters. This specimen is of a typical Cockerell make and was overlooked as a type by Stanbury (1969).

Two specimens from Alex Morton’s series of “*Ptilinopus eugeniae*” from Ugi were sent to Salvadori in 1883. One of these specimens is now in the Museo Regionale di Scienze Naturali, Torino. The specimen, A.11549 (now = 6221) has a white head and is thus definitely a *Ptilinopus eugeniae* and is not a type (pers. obs., 1 September 1994; confirmed by C. Pulcher in litt., 1 July 2003). Salvadori sent the other specimen to Doria in Genova. Specimen A.11552 (now = CE 22541) is still in the collections of the Museo Civico di Storia Naturale “Giacomo Doria”, but is also not a type of *P. lewisi* (pers. obs., 30 August 1994; confirmed by E. Borgo in litt., 18 September 2003).

Baza gurneyi Ramsay, 1882, *Journal of the Linnean Society (London)* 16: 130.

[= *Aviceda subcristata gurneyi* (Ramsay, 1882)]

Australian Museum. Lectotype: A.10962.

The specimen lacks an original label. The register lists the specimen as coming from Ugi and being bought from “J. Stephens party”. Longmore (1991) selected this specimen as the lectotype. This taxon was described by Ramsay from specimens collected at Ugi by Reverend George Brown, and at Cape Pitt by Cockerell (Ramsay, 1882b). On this basis there could be some doubt as the selection of the lectotype. Nevertheless, it appears Ramsay made an error with the collector of the Ugi specimens. His diary records a small collection received from Brown in mid-1881 (Ramsay diaries, Mitchell Library ML.MSS 2278 Add on 544). This collection includes specimens from Ugi, but there are no birds of prey amongst them and so it appears the specimen from Ugi came from another source. Although it seems that Longmore’s selection of the lectotype was correct, the specimens he considered paralectotypes cannot have that status. Five of those in the Australian Museum; A.11486, A.11487, A.11489, A.11490, and A.11491, lack original tags. The register notes that these specimens were collected by Alex Morton at Ugi and were registered in December 1881. It is clear from the paper in which *Baza gurneyi* was named that Alex Morton was still collecting for Ramsay in the Solomon Islands at the time the paper was sent to London, so none of these specimens can be types (Ramsay, 1882b). This also is the case for Queensland Museum specimen

O.17872, previously A.11488 in the Australian Museum collection, which was exchanged with the Queensland Museum in June 1883 (H. Janetzki, in litt.). This specimen was referred to by Longmore (1991) though no details were given. In addition Australian Museum specimen O.22343, collected by Cockerell, was claimed by Longmore (1991) to be a type, but it is from New Britain and is not part of the type series (see also below).

Macleay Museum. One paralectotype: B.2937.

Labelled as “Baza? Reinwardti, Solomon Islands” in Masters’ hand, this specimen is of a typical Cockerell make. Ramsay (1879b) noted that there was a single specimen in Cockerell’s collection from the Solomon Islands from “Cape Pitt”, in the New Georgia group, which at the time he considered indistinguishable from specimens from Port Moresby in New Guinea. Mayr (1945b) pointed out that birds from New Georgia were similar to an undescribed taxon from the Bougainville and Shortland groups, which he named *proxima*. Mayr considered that Ramsay had been in error in associating Cape Pitt birds with *gurneyi* as Mayr considered they were found from Guadalcanal eastwards (a view still held in Mayr & Diamond, 2001). Nevertheless, Schodde (1977) disagreed with Mayr’s assessment and considered there was only one subspecies found in the Solomon Islands, *Aviceda subcristata gurneyi*. In Schodde’s view then, although the type locality was restricted to Ugi by Mayr (1945b), the bird collected by Cockerell at Cape Pitt was the subspecies *gurneyi*. Ferguson-Lees *et al.* (2001) followed Mayr in recognition of *proxima*, though Dickinson (2003), Dutton (2011) and Dickinson & Christidis (2014) followed Schodde (1977). Longmore (1991) solved the problem of the type locality by selecting the lectotype from Ugi. He identified a specimen of *Aviceda subcristata* collected by Cockerell on New Britain as being the specimen from Cape Pitt. However, Ramsay does not state that Cockerell’s Cape Pitt specimen was actually in his possession when he described the taxon. Given that B.2937 was collected by Cockerell in the Solomons, and that only one specimen was said by Ramsay (1879b) to be in Cockerell’s collection from these islands, the Australian Museum specimen from New Britain cannot have any type status. The Macleay Museum specimen was overlooked as a type by Stanbury (1969) and Longmore (1991).

Astur pulchellus Ramsay, 1882, *Journal of the Linnean Society (London)* 16: 131.

[= *Accipiter hiogaster pulchellus* (Ramsay, 1882)]

Australian Museum. Holotype: A.3813.

This specimen lacks an original label and was originally registered under the name “*Astur soloensis*” though this entry was replaced with “*A. pulchellus*” in the register. The register lists it as the type specimen and as a male from “Guadalcanar”, bought from “Capt Brodie & Cockerell”. Salvadori (1880) suggested that Ramsay’s use of *Astur soloensis* in his first 1879 *Proceedings* paper was incorrect. This may have prompted Ramsay to re-examine the specimen. Note that Schodde (1977) and Ferguson-Lees *et al.* (2001) considered *pulchellus* to be part of the *Accipiter hiogaster* species complex.

Cinnyris melanocephalus Ramsay, 1879, *Nature* 20: 125, (5 June 1879) and

Cinnyris (?) *dubius* Ramsay, 1879, *Proceedings* 4: 83–84, (16 June 1879).

[= *Myzomela melanocephala* (Ramsay, 1879)]

This species was named by Ramsay in his first paper that used Cockerell's collections, at a time where he had viewed the entire collection. Any specimens of this taxon that can be identified as collected by Cockerell are thus types.

Australian Museum. Five syntypes: O.18738, O.18739, A.3918, A.3919, A.3920, as recorded by Longmore (1991). O.18738, ex Dobroyde collection, registered 1912. Labelled as a type of "*Cinnyris dubius*" and a male. O.18739, ex Dobroyde collection, registered 1912. Labelled as a type of "*Cinnyris dubius*" and a probable female. A.3918, A.3919 and A.3920 do not have original labels. The register notes that all three are types of "*Cinnyris melanocephalus*" and were collected by "Capt. Brodie & Cockerell".

Museum Victoria. Three syntypes: B.19563, B.19564, B.19565. All three are labelled on another tag: Cockerell's Solomon Isds Coll.; Jan.23/79. The specimens have the following details on the strip wrapping: B.19563, Solomon Isl., Oct 78, male; B.19564, Solomon Isl., Oct 78, female; B.19565, Solomon Isl., Oct 77 [sic, lapsus for 78], female.

Macleay Museum. Two syntypes: B.2849; B.2850. Both are labelled "*Cinnyris melanocephala*, Ramsay. Solomon Is." by Masters. These specimens are both of a typical Cockerell make and were overlooked as types by Stanbury (1969).

Graucalus pusillus Ramsay, 1879, *Proceedings* 4: 71, and

Graucalus solomonensis Ramsay, 1879, *Proceedings* 4: 314 (replacement name for *G. pusillus*).

[= *Coracina lineata pusilla* (Ramsay, 1879)]

Australian Museum. Lectotype: O.18714. This specimen is from the Dobroyde collection and was registered in 1912. It was labelled by Ramsay as a type of *Graucalus pusillus* from the Solomons and as a possible adult male. One paralectotype: O.18713.

Also from the Dobroyde collection and registered in 1912, this specimen was labelled by Ramsay as a type of *Graucalus pusillus* from the Solomons. The sex was not noted.

Schodde (1977) designated the lectotype, but did not note the paralectotype which was found later by Longmore (1991). Ramsay (1879c) gave it the replacement name of *G. solomonensis*. Ramsay evidently believed the replacement name was necessary as Sharpe (1879) had referred to "*Campephaga pusilla* Blyth". Sharpe referred to Gray (1869) as the source of Blyth's name. Several authors (e.g., Mathews, 1930; Mayr, 1945a; Galbraith & Galbraith, 1962) have followed Ramsay, but as pointed out by Schodde (1977) the name as published in Gray is a *nomen nudum* and no other reference by Blyth to the name as quoted by Gray is known. Consequently the valid name must remain as *Coracina lineata pusilla*.

Graucalus elegans Ramsay, 1881, *Nature* 24: 277.

[= *Coracina papuensis elegans* (Ramsay, 1881)]

Ramsay originally did not give the source of the specimens from which he named this taxon. In his following *Proceedings* paper (Ramsay, 1881b) he noted that most of the taxa were provided by Lieutenant Richards. However, *Graucalus elegans* was collected by Cockerell on "Guadalcanar". After his listing of the scientific name Ramsay referred to "*Graucalus hypoleucus*, Ramsay, P.L.S., of N.S.W.". This is a clear reference to Ramsay's first *Proceedings* paper of 1879 where Ramsay commented on Cockerell's specimens from Guadalcanal under the name *Graucalus hypoleucus*. Ramsay had seen all Cockerell's Solomons specimens before writing the 1879 paper and thus Ramsay's reference to this paper in his 1881 account means that the specimens in Museum Victoria, the Macleay Museum and Milan are also syntypes.

Australian Museum. Three syntypes: A.3822, A.3824, A.3825. A.3822, labelled as a male "*Graucalus hypoleucus* Gould" from "Guadalcanar". A.3824, labelled as a male "*Graucalus hypoleucus* Gould" from "Guadalcanar". A.3825, labelled as a female "*Graucalus hypoleucus* Gould" from "Guadalcanar". The register notes that all three were collected by "Capt. Brodie & Cockerell".

These specimens were identified as syntypes by Longmore (1991). Specimen A.3823 was also registered with the same details but has not been located. This missing specimen was probably exchanged with Finsch and now in the collection in Milan. Even though at least three of these four specimens were in front of Ramsay at the time of the description of *Graucalus elegans*, neither the labels nor the register were adjusted to show these specimens were types.

Museum Victoria. Four syntypes: B.19570, B.19571, B.19572, B.19573. These specimens have the following details on the strip wrapping: B.19570, Solomon Isl., Oct 78, male; B.19571, Guadalcanar [= Guadalcanal], Solomon Island[s], No 78, female; B.19572, Solomon Island[s], No 78, female; B.19573, Lanio, Solomon Isld, female. All four are labelled on additional tags: "Cockerell's Solomon Isds Coll.; Jan.23/79".

Macleay Museum. Three syntypes: B.4892, B.4893, B.4894. These three specimens were labelled by Masters "*Graucalus*. Solomon Is.". They are of typical Cockerell make and although not sexed are adults, and were overlooked as types by Stanbury (1969).

Museo Civico di Storia Naturale, Milano. One syntype. In the Museo Civico di Storia Naturale, Milano there is a specimen of this taxon of Cockerell make which came to the Museum in 1882, undoubtedly being originally acquired from Ramsay by Otto Finsch (McAllan *et al.*, 2005). It is labelled as a male "*Graucalus elegans* or *minor* Ramsay, sp. nov. Ramsay" with the locality "Guadalcanal" (pers. obs., 2 September 1994). Ramsay kept a visitors book at the Australian Museum now lodged with the Mitchell Library (in uncatalogued material). Finsch visited the Australian Museum on 29 August 1881. Although there is no account of the visit, the letter from Finsch to Ramsay indicates duplicate specimens were exchanged between them at this meeting (McAllan *et al.*, 2005). Ramsay named the taxon at a meeting of the Linnean Society of NSW on 23 February 1881, and it first appeared in print in *Nature* on 21 July 1881, though it

did not appear in the *Proceedings* until 12 September 1881. Thus the form was still a novelty when Finsch visited, and it is likely that Ramsay would have shown Finsch specimens of this taxon.

P[seudorectes] cinnamomeum Ramsay, 1879, *Nature* 20: 125.

[= *Pachycephala orioloides cinnamomea* (Ramsay, 1879)]

Australian Museum. Two syntypes: A.3831, A.3832.

Both these specimens have labels in the hand of Ramsay as being “*Pachycephala orioloides*” and coming from “Guadalcanar”, A.3831 is labelled as a juvenile male and A.3832 as a female. The register notes that both were collected by “Capt. Brodie ‘Ariel’ & Cockerell”. Ramsay described a bird with female plumage in *Nature*, but did not note the sex of the bird described. He did not describe the taxon in his first 1879 *Proceedings* paper where he gave a description of a female *Pachycephala* from Guadalcanal under the name “*Pachycephala orioloides*”. Longmore (1991) listed A.3832 as an adult male, however it is a female and thus still a type. The immature male has a similar plumage to the female.

Museum Victoria. One syntype: 45732.

This specimen is a mount in female plumage. The socle on the mount is labelled “*Pachycephala astrolabi* Bp. Solomon Islds.” The register notes it as having been collected by Cockerell in the Solomons with the date January 1879, obviously the date of acquisition by the Museum. It was registered in May 1884, originally under the name “*Pachycephala oriolus*”. This was crossed out in the register and replaced by “*orioloides*” and again replaced by “*astrolabi*”. There are an additional four male specimens sent by Cockerell to Museum Victoria (B.9945–9). Three of these are in adult male plumage and cannot be types. The other specimen, B.9949 is an immature bird which was identified as not being *cinnamomea* by “I.C.J.G.” (= Ian Galbraith, the author of a revision of the *Pachycephala pectoralis* superspecies [Galbraith, 1956]). Yet the locality of “Gaudalcana” on the strip wrapping tag alone, as well as the fact that Cockerell only collected within the range of *cinnamomea*, suggests that this comment is incorrect. This specimen was collected when the bird was in the process of acquiring adult plumage and has a yellow wash to the belly and vent and so cannot be a type.

S[auloprocta] cockerellii Ramsay, 1879, *Nature* 20: 125, (5 June 1879) and

Sauloprocta (?) *cockerelli* Ramsay, 1879, *Proceedings* 4: 81–82, (16 June 1879).

[= *Rhipidura cockerellii cockerellii* (Ramsay, 1879)]

As with *Cinnyris melanocephalus*, this species was named after Ramsay had already viewed Cockerell’s entire collection. Any specimens of this taxon that can be identified as collected by Cockerell are thus types. Dickinson & Christidis (2014) considered that Ramsay acted as first revisor. However, Dickinson & Christidis did not give any

reference to the paper in which this occurred. It was not in the following *Proceedings* paper where there was no mention of the paper in *Nature*.

Australian Museum. Three syntypes: O.18716, A.3848, A.3849. O.18716, ex Dobroyde collection, registered 1912. This specimen was labelled by Ramsay as a type from the Solomons with the sex as “male”. A.3848 and A.3849, are labelled in Ramsay’s hand as types of the species from “Guadalcanar”. Both are marked as “male?”.

Museum Victoria. Three syntypes: B.19549, B.19550, B.19551. These specimens have the following details on the strip wrapping: B.19549, Solomon Isl., Oct 77 [sic, lapsus for 78], female; B.19550, Solomon Isl., Oct/ 78/ male; B.19551, Solomon Isl., Oct 78, male. All three are labelled on additional tags: “Cockerell’s Solomon Isds Coll.; Jan.23/79”.

Macleay Museum. Two syntypes: B.7131, B.7132.

Both specimens were labelled by Masters “*Sauloprocta Cockerellii*, Ramsay. Solomon Is.” and are of a typical Cockerell make. Stanbury (1969) referred to both specimens as possible types.

R[hissidura] rufofronta Ramsay, 1879, *Nature* 20: 125, (5 June 1879) and

Rhipidura (?) *rubrofrontata* Ramsay, 1879, *Proceedings* 4: 82–83, (16 June 1879).

[= *Rhipidura rufifrons rubrofrontata* (Ramsay, 1879)]

Ramsay corrected the spelling to *rubrofrontata* in 1881 (Ramsay, 1881b), specifically mentioning his 1879 *Nature* paper (see also Longmore, 1991). Consequently it can be considered a valid emendation under the International Code of Zoological Nomenclature (ICZN, 1999) and stands with the corrected spelling (*contra* Dickinson, 2003 and Dickinson & Christidis, 2014). Note this is different from the other changes in names between papers in *Nature* and their immediately analogous *Proceedings* papers where there is no reference to the earlier papers.

Australian Museum. One syntype: A.3851.

This specimen is labelled in Ramsay’s hand as a type of *Rhipidura rubrofrontata* from “Guadalcanar” and a possible adult male.

Museum Victoria. Two syntypes: B.19561, B.19562.

Both are labelled on the strip wrapping as coming from the Solomon Islands and as males. The date “Oct 78” is also written on both. They are labelled on additional tags, “Cockerell’s Solomon Isds Coll.; Jan.23/79”.

Macleay Museum. One syntype: B.7090.

This specimen was labelled by Masters “*Rhipidura rufofrontata*, Ramsay. Solomon Is.”. It is of a typical Cockerell make and was overlooked as a —type by Stanbury (1969).

The Natural History Museum. One syntype: 1895.12.21. 136. Warren & Harrison (1971) claimed this specimen was a holotype, however Ramsay did not designate a type, as noted by Longmore (1991). Furthermore, as noted above, Ramsay saw Cockerell’s full collection before describing this taxon in the first paper. Warren & Harrison note that the

specimen came from "Lango, Guadalcanar". This locality is given on the early British Museum label, but not on the oldest label attached to the specimen which simply notes "Solomon Islands" (M. Walters, in litt.). The latter locality is also written in the register. The specimen was "received in exchange" from Ramsay, but there is no indication of any such exchange in the Australian Museum registers, and so the specimen evidently came from the Dobroyde collection.

Myiagra ferocyanea Ramsay, 1879, *Nature* 20: 125, (5 June 1879) and

Myiagra (?) ferro-cyanea Ramsay, 1879, *Proceedings* 4: 78–79, (16 June 1879).

[= *Myiagra ferrocyanea ferrocyanea* Ramsay, 1879]

Ramsay initially named this species *M. ferocyanea* in *Nature*, but in his following paper in the *Proceedings* he used the spelling *M. ferro-cyanea* (Ramsay, 1879b). Ingram (1987) and Longmore (1991) suggested this act was an emendation by Ramsay. This is not strictly true, as Ramsay never mentioned the *Nature* paper in his 1879 *Proceedings* account. Nevertheless, it appears Ramsay sent the paper to *Nature*. Later Ramsay used the spelling *M. ferrocyanea* and referred to the 1879 *Proceedings* paper (Ramsay, 1882f). Elsewhere in this 1882 paper he used the name *Cinnyris melanocephalus* as used in *Nature* and not *C. dubius* which was listed in synonymy. In his 1881 *Proceedings* paper he specifically mentioned the 1879 paper in *Nature*. This indicates that he was aware of the 1879 *Nature* paper and thus the spelling of *M. ferrocyanea* as used in the 1882 paper was a valid emendation under the ICZN (1999).

As early as his first 1879 *Proceedings* paper Ramsay suggested that his *M. pallida* may refer to females of *M. ferrocyanea*. Salvadori (1880) merely noted Ramsay's indecision about this taxon. Tristram (1882) again suggested that these could be the same species, but did not make a definite decision. Later Tristram (1892) noted a female specimen of *M. ferrocyanea* in a collection from the Solomons, but did not say how he disposed of the name *M. pallida* and so did not act as first revisor as required by the ICZN (1999). It was not until 1901 that Rothschild & Hartert finally acted as first revisors by noting under the heading *Myiagra ferrocyanea*, "There is no doubt that *Myiagra pallida* of Ramsay is the female of *M. ferrocyanea*" (Rothschild & Hartert, 1901).

Australian Museum. Four syntypes: O.18720, A.3833, A.3835, A.3837. O.18720, ex Dobroyde collection, registered 1912. This specimen was labelled by Ramsay supposedly in December 1878, though as the ship did not arrive in Sydney until 6 January 1879, this is presumably an error for the collection date. It is labelled as a type of *Myiagra ferrocyanea* from the Solomons. The sex was given as "male?". A.3833, labelled by Ramsay as a type from "Guadalcanar" and a male. A.3835, labelled by Ramsay as a type from "Guadalcanar" and a probable male. A.3837, labelled by Ramsay as a type from "Guadalcanar" and a possible female. This was evidently an error by Ramsay as he had named the females of this species *Myiagra pallida* (see below). The last three specimens are listed in the register as having been collected by "Capt Brodie 'Ariel' & Cockerell".

Museum Victoria. Five syntypes: B.19552, B.19553, B.19554, B.19555, B.19556. These specimens have the following details on the strip wrapping: B.19552, Solomon Isl., Oct 78, male; B.19553, Solomon Isl., Oct 78, male; B.19554, Solomon Isl., Oct/78/ male; B.19555, G [= Guadalcanar], Solomon Isl., Dec 77 [the second 7 crossed out], male; B.19556, Solomon Isl., Oct 77 [the second 7 crossed out], male. The first four are labelled on additional tags: "Cockerell's Solomon Isds Coll.; Jan.23/79", but B.19556 has no additional tag.

Macleay Museum. Four syntypes: B.7265, B.7266, B.7267, B.7268. All four specimens were labelled by Masters "Myiagra ferro-cyanea. male. Solomon Is." and are of typical Cockerell make. Stanbury (1969) referred to these specimens as possible types.

Queensland Museum. One syntype: O.20855.

Longmore (in Ingram, 1987) noted that Ramsay sent a syntype (Australian Museum specimen A.3834) on exchange to the Queensland Museum. A mounted specimen in the Queensland Museum, number O.20855, was believed by Ingram (1987) to be the specimen in question.

The Natural History Museum. One syntype: 1884.1.19.10. According to Warren & Harrison (1971) this specimen came from "Guadalcanar, Solomons" with the date "Dec. 1879". The specimen is actually labelled "Solomon Islands", as is the register, with no mention of "Guadalcanar" (M. Walters, in litt.). The label also notes "ex P.R. 12.1879", though it may be that "ex P.R." refers to E. P. Ramsay. The date is after the description of the taxon and may be the date of receipt (M. Walters, in litt.). The specimen was purchased by The Natural History Museum directly from Cockerell. Given the date of receipt it is evident that the specimen was part of the original collection and thus seen by Ramsay.

Myiagra pallida Ramsay, 1879, *Nature* 20: 125.

[= *Myiagra ferrocyanea ferrocyanea* Ramsay, 1879, see Rothschild & Hartert (1901)]

Australian Museum. Four syntypes: O.18722, A.3838, A.3839, A.3840. O.18722, ex Dobroyde collection, registered 1912. This specimen was labelled by Ramsay supposedly in December 1878, though this could be the date of collection. It is labelled as a type of *Myiagra pallida* from the Solomons. The sex of this specimen was not recorded. A.3838, labelled by Ramsay as a type from "Guadalcanar" and a probable male. A.3839, labelled by Ramsay as a type from "Guadalcanar" with sex initially not determined and then replaced with male. A.3840, labelled by Ramsay as a type from "Guadalcanar" and a probable female.

As with *M. ferrocyanea* the sexes of A.3838 and A.3839 are incorrect, as *M. pallida* should only refer to females. This incorrect sexing of the specimens of both *M. ferrocyanea* and *M. pallida* by Cockerell evidently resulted in Ramsay never being fully convinced that only one species was involved.

Museum Victoria. Four syntypes: B.19557, B.19558, B.19559, B.19560. All four have tags labelled: "Cockerell's Solomon Isds Coll.; Jan.23/79". B.19557, notes on the strip

wrapping, Solomon Isl., Oct 78, female. B.19558, notes on the strip wrapping, G. [= Guadalcanal] Solomon Isl., Oct 77 [sic, lapsus for 78], female. This specimen has the additional note “Myiagra ferrocyanea feminina, L.W. Filewood det 5/4/[19]76” on the reverse of the attached tag, although this identification is clearly incorrect on the basis of the collecting locality alone. B.19559 and B.19560 both lack the original strip wrapping, but are of typical Cockerell make.

Macleay Museum. Two syntypes: B.7269, B.7270.

Both specimens were labelled by Masters “Myiagra pallida, Ramsay. Solomon Is.” with later annotation in pencil that the specimens are female. They are both of a typical Cockerell make and Stanbury (1969) referred to them as possible types.

The Natural History Museum. One syntype: 1884.1.19.11. According to Warren & Harrison (1971) this specimen came from “Guadalcanar, Solomons” and has “Jan. 1879” written on an attached label. This date corresponds with the date of the meeting of the Linnean Society of NSW at which the bird was described. The register and labels on the specimen simply state that the bird came from the Solomon Islands (M. Walters, in litt.). The specimen was purchased by The Natural History Museum directly from Cockerell.

M[onarcha] barbata Ramsay, 1879, *Nature* 20: 125, (5 June 1879) and

Monarcha (?) *brodiei* Ramsay, 1879, *Proceedings* 4: 80–81, (16 June 1879).

[= *Symphysarchus barbatus* (Ramsay, 1879)]

Australian Museum. Four syntypes: O.18723, O.18724, O.18725, A.3847. O.18723, ex Dobroyde collection, registered 1912. Labelled by Ramsay as type of *Monarcha brodiei* from the Solomons and also as “? male juv.” and “Type of sp. female”. It is an immature bird with one black feather on the throat indicating it is moulting into adult plumage. O.18724, ex Dobroyde collection, registered 1912. Labelled by Ramsay as type of *Monarcha brodiei* from the Solomons and also as “Type of species male”. It is an adult bird. O.18725, ex Dobroyde collection, registered 1912. Labelled by Ramsay as type of *Monarcha brodiei* from the Solomons and also as “Type of species juv male”. It is also an immature bird with one black feather on the throat indicating it is moulting into adult plumage. A.3847 is an immature bird with some black feathers on the throat indicating it is moulting into adult plumage. Half of Ramsay’s tag is missing, though it does indicate that it is a *Monarcha* from Guadalcanal. The register notes it is a juvenile male and a type of “*Monarcha barbata*”, the latter being crossed out and replaced with “*brodiei*”.

When Ramsay named *Monarcha barbatus* there was no description of juvenile or immature plumage, merely noting “*M. barbata*, with elongated black plumes from the throat, belonging to the *M. loricata* and *M. leucotis* section”. In this sense all four specimens could conceivably be considered syntypes of *M. barbatus* as all have at least one black feather on the throat, and such a view was taken by Longmore (1991). However, if a more strict view is taken,

that Ramsay was only referring to adults, the three immature birds could still be considered syntypes of *M. brodiei* which did include descriptions of “Adult female and young male” and “Progress towards maturity”.

Macleay Museum. One syntype: B.7224.

Ramsay described birds with black feathers on the throat of *M. barbatus* in his paper in *Nature*. B.7224, an adult bird and labelled by Masters “*Monarcha Brodiei*, Ramsay. Solomon Is.”. Another specimen, B.7225, is an immature bird, lacking black feathers on the throat. It was labelled by Masters as “*Monarcha barbata*, (young?) Solomon Is.”, and although it cannot be considered a type of *M. barbatus*, it still qualifies as a syntype of *M. brodiei*. Both specimens are of a typical Cockerell make. Stanbury (1969) only referred to one type in the collection, presumably B.7224.

M[onarcha] rufocastanea Ramsay, 1879, *Nature* 20: 125.

[= *Monarcha castaneiventris castaneiventris* Verreaux, 1858]

Australian Museum. Seven syntypes: O.18726, O.18727, A.3841, A.3845, A.3846, and two further specimens.

O.18726, ex Dobroyde collection, registered 1912. This specimen was labelled by Ramsay with the date December 1878. Given the *Ariel* left the Solomons on 21 December 1878 this may refer to the collection date. It is labelled as a type from the Solomons and an adult male. O.18727, ex Dobroyde collection, registered 1912. This specimen was labelled by Ramsay in December 1878 as above. It was labelled as a type from the Solomons and a juvenile male. A.3841, no original label. The register notes this specimen as an adult, sex possibly male. A.3845, no original label. The register notes this specimen as an adult female. A.3846, no original label. The register notes this specimen as an adult sex possibly female.

The last three specimens were not noted by Longmore (1991). The register notes that these three specimens were types of “*Monarcha rufocastanea*” and collected on “Guadalcanar” by “Capt Brodie ‘Ariel’ & Cockerell”. The scientific name was crossed out and replaced with “*Pomarea castaneiventris* Verr.”. Ramsay discovered that *Monarcha castaneiventris* had priority over *M. rufocastanea* soon after he described it (Ramsay, 1879c).

At the time this paper was originally written, three specimens listed in the register as being types could not be found. The specimens, A.3842, A.3843 and A.3844 were not recorded as exchanged or destroyed. Subsequently a large number of specimens in the bird collection were discovered to have been misappropriated by a former AM employee. Two of the specimens recovered by the NSW Police were of this taxon and are of a Cockerell make. However, their original tags were mutilated and their registration numbers removed. As the registration numbers are unlikely to be resolved, the specimens may ultimately need to be re-registered into the Australian Museum collection with new numbers.

Museum Victoria. Four syntypes: B.19545, B.19546, B.19547, B.19548. These specimens have the following details on the strip wrapping: B.19545, Solomon Isl., No/78, female; B.19546, Solomon Isl., Oct 77 [the second 7 has been crossed out], female, Gaudal [= Guadalcanal]; B.19547, Guadalcanal [= Guadalcanal], Solomon Isl., Oct 77 [the second 7 has been crossed out and replaced with an 8], male; B.19548, Solomon Isl., Oct/79/ male. All four are labelled on another tag: "Cockerell's Solomon Isds Coll.; Jan.23/79".

Macleay Museum. Four syntypes: B.7194, B.7915, B.7196, B.7197. All four specimens were labelled by Masters "Monarcha castaneiventris Verr. Solomon Is." and are of typical Cockerell make. These specimens were overlooked as types by Stanbury (1969).

[*Calornis solomonensis* Ramsay, 1879, *Nature* 20: 125.]

[= *Aplonis cantoroides* (Gray, 1862)]

Longmore (1991) noted a type of this taxon in the Australian Museum. However, the specimen so designated, A.3862, is an immature bird with black streaking on a white undersurface. Ramsay's original description noted that *solomonensis* was "a uniform bright steel green" which strongly suggests that an adult bird was used in the description. No such bird is found in the known surviving Cockerell material. Ramsay did not describe this taxon in his first 1879 *Proceedings* paper, though he listed *Calornis cantoroides* and noted both adult male and "female" [sic = immature] birds.

In summary, type specimens collected by Cockerell and named by Ramsay were dispersed to six museums, with significant numbers being in the Australian Museum, Museum Victoria and the Macleay Museum as shown in Table 3.

Table 3. Numbers of specimens of Ramsay's types collected by Cockerell in different museums. * = valid taxa. AM, Australian Museum; NMV, Museum Victoria; MM, Macleay Museum, the University of Sydney; QM, Queensland Museum; BMNH, The Natural History Museum, Tring, UK; MSNM, Museo Civico di Storia Naturale, Milano, Italy. Figures in square brackets are missing specimens. Specimens of *Myiagra brodiei* in the Macleay Museum are distinguished from those of *M. barbata* in the listings but not the totals.

Ramsay's names for the taxa	AM	NMV	MM	QM	BMNH	MSNM	Total
<i>Macropygia rufocastanea</i>	1	—	—	—	—	—	1
* <i>Ptilopus lewisii</i>	1 [1]	—	1	—	—	—	2 [1]
* <i>Baza gurneyi</i>	1	—	1	—	—	—	2
* <i>Astur pulchellus</i>	1	—	—	—	—	—	1
* <i>Cinnyris melanocephalus</i>	5	3	2	—	—	—	10
* <i>Graucalus pusillus</i>	2	—	—	—	—	—	2
* <i>Graucalus elegans</i>	3 [1]	4	3	—	—	1	11+[1]
* <i>Pseudorectes cinnamomeum</i>	2	1	—	—	—	—	3
* <i>Sauloprocta cockerellii</i>	3	3	2	—	—	—	8
* <i>Rhipidura rubrofrontata</i>	1	2	1	—	1	—	5
* <i>Myiagra ferrocyanea</i>	4	5	4	1	1	—	15
<i>Myiagra pallida</i>	4	4	2	—	1	—	11
* <i>Monarcha barbata</i> (<i>M. brodiei</i>)	5	—	1 (2)	—	—	—	7
<i>Monarcha rufocastanea</i>	7 [1]	4	4	—	—	—	15 [1]
<i>Calornis solomonensis</i>	1?	—	—	—	—	—	1?
Total	40 [3]+1?	26	22	1	3	1	93 [3]+1?

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Submit manuscripts and images separately and electronically; images should be high resolution TIFFs (see below). Attach one summary file giving: the title; the name, address and email of each author; the author responsible for checking proofs; a suggested running-head of less than 40 character-spaces; and the number of figures, tables and appendices. Manuscripts must be complete when submitted.

Tables and figures should be numbered and referred to in numerical order in the text. Authors should avoid excessive layout or textual embellishments; a single font should be used throughout.

All copy is manipulated within a Windows (not Mac) environment using Microsoft and Adobe software. Maps should be submitted as high resolution TIFF.

Manuscripts should be prepared using recent issues as a guide. There should be a title (series titles should not be used), author(s) with their institutional addresses, an abstract (should be intelligible by itself, informative not indicative), introduction (should open with a few lines for general, non-specialist readers), materials and methods, results (usually subdivided with primary, secondary and rarely tertiary-level headings), discussion, acknowledgments and references. If appropriate, an appendix may be added after references.

In the titles of zoological works the higher classification of the group dealt with should be indicated. Except for common abbreviations, definitions should be given in the materials and methods section. Sentences should not begin with abbreviations or numerals; generic names should not be abbreviated if at the beginning of a sentence. Metric units must be used except when citing original specimen data. It is desirable to include geo-spatial coordinates; when reference is made to them, authors must ensure that their format precludes ambiguity; in particular, avoid formats that confuse arcminutes and arcseconds.

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